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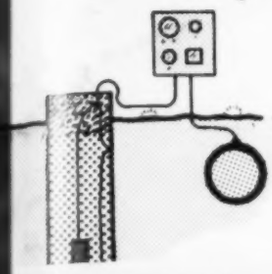
Bare Pipe Protected With Deep Groundbeds



Long life graphite rods in 250 feet deep beds make cathodic protection in high resistance soil economical . . . p. 40

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PIPE LINE INDUSTRY

CONSTRUCTION • OPERATIONS • MAINTENANCE

OCTOBER 1958

COMPRESSOR DESIGN

Series-Parallel Centrifugals Proven 45

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PERSONAL SAFETY

Don't Bet Your Life on Unsafe Habits 65

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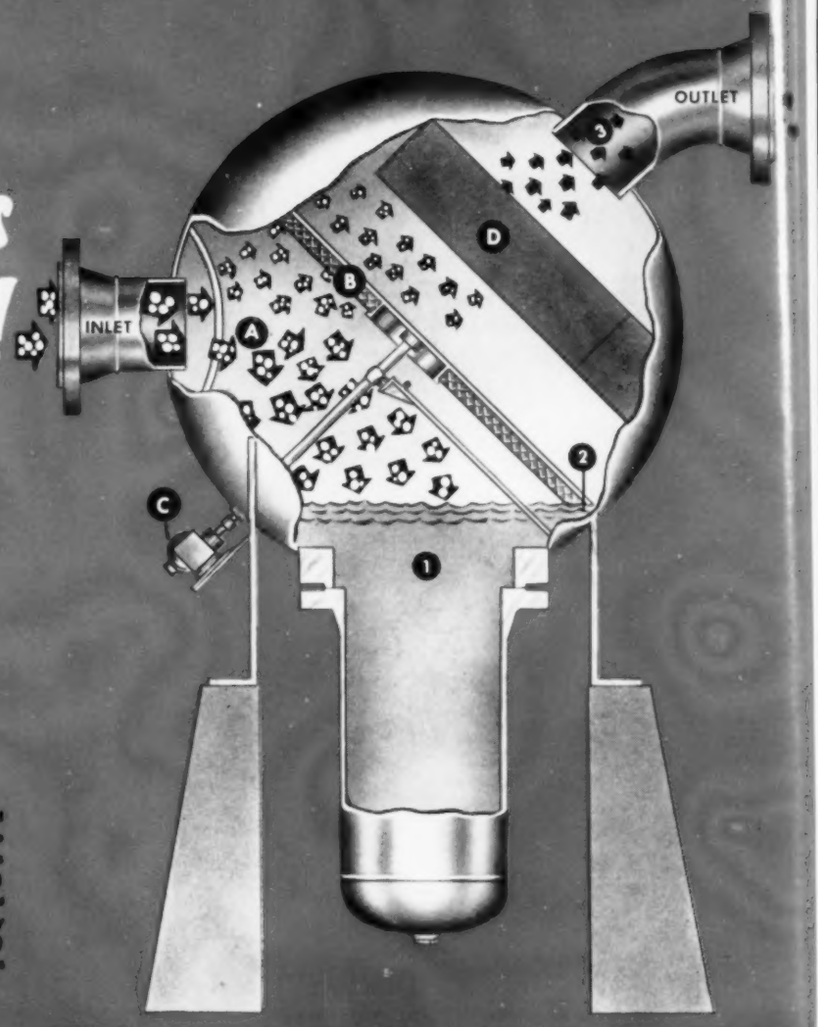

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PIPE LINE INDUSTRY

CONTENTS and Quick Look

October, 1958 Vol. 9, No. 4

To help you put first things first, scan these time-saving digests, checking ☑ those you want to read first.

Deep Groundbeds for Line Protection

☐ Recent developments in engineering deep ground beds have made the cathodic protection of bare pipe lines in high resistance soil economical. Here is the description of the design of a new type deep bed employing graphite rods and coke breeze backfill that has successfully completed initial field tests.

By Robert L. Bullock.....Page 40

Series-Parallel Centrifugal Compressor Provides Pumping Flexibility

☐ The unique design of this compressor gives the operating flexibility of reciprocating stations to turbine driven-centrifugal stations over the normal compression ratios. Actually two compressors in one case, the unit consists of four impellers. Polytropic efficiencies as high as 80 percent have been obtained with new designs.

By Robert E. Schuhmann.....Page 45

Pipe Stress in Offshore Pipe Line Construction

☐ Here is a mathematical analysis of pipe stress which can be expected in offshore pipe line construction. Formulas are derived with special emphasis on the negative buoyancy method. From this analysis and derivation, specifications were written and various methods of launching the pipe were evaluated.

By Noah Roads.....Page 51

How TGT Uses Computers to Analyze Compressor Station Operations

☐ Operating records of more than 500 engines are being given a continuing study by Tennessee Gas Transmission Company's electronic computer planning team to produce timely and accurate reports for operating management evaluation. Data from daily compressor station reports are fed into the computer along with fixed master card data to quickly generate a report showing horsepower-hours run, calculated sweep volumes, oil use, repairs and various operating conditions for each engine. Answers sought in future studies may include such items as best time for crankshaft renewals, spare parts stocks need and where, most efficient combination of engines and optimum loading conditions for stations on the line.

By John T. Manry, III.....Page 55

Lengthen the Life of Antifriction Bearings—Influence of Design Factors (Part 2)

☐ A better understanding of the design of a particular bearing should help to improve maintenance routines for either construction machinery or station equipment. This knowledge is even more essential when replacing parts or modifying machinery. Covered here are the five basic types of ball bearings, modifications of these types, units for radial or thrust loads, plus common types of roller bearings found in pipe line equipment. (Part 1 covering maintenance and including a complete troubleshooting checklist appeared in the September, 1958, issue.)

By Johnny Riddle.....Page 60

Don't Bet Your Life on Unsafe Habits

☐ One insurance survey revealed that in 300 accidents there were 30 injuries with only one requiring hospitalization. However, constant exposure to unsafe acts and conditions can cut down these odds. Here's an article which tells how every supervisor can reduce accidents by learning to recognize and eliminate those unsafe acts and conditions.

By J. A. Gavin.....Page 65

Just What Do These Corrosion Terms Mean?

☐ As an aid to corrosion control communications, the InterSociety Corrosion Committee's sub-committee on Standard Definitions and Terminology has compiled and recommended a list of standard corrosion definitions. A list of terms of special interest to pipelines has been abstracted from the complete list. Misunderstanding of corrosion reports can be eliminated through use of this list of standard terms.....Page 75

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PIPE LINE INDUSTRY published every month. Entered as second class mail matter July 9, 1954, at the post office at Houston, Texas, under the act of March 3, 1879.

Not perfect, but better

From the federal government has come another move designed to control imports of foreign crude oil. This latest program, evolved by U. S. Imports Administrator Matthew V. Carson, Jr., and tailored by a government task force, changes the method of controlling oil imports. The proposal would substitute a percentage-of-refinery-run control for the historical allocation system.

In seeking the most equitable manner of better controlling crude imports, Captain Carson set aside a period of 30 days in which industry's comments on the new program will be accepted for study. At the end of this "study period," it is likely that the new voluntary program or a modified version will go into effect.

This proposed program will run the old and familiar gamut of opinion—from outright support to vehement dislike. That is to be expected since, under the new approach, oil imports of some companies will be increased, others will remain at present levels and still others will be reduced. Differences of opinion naturally can be expected to follow the trend of the impact of the new program on individual companies.

But regardless of how much is written or what is said in criticism of the proposal, it represents an improvement over the present system from an over-all industry viewpoint.

For the first time, imports would be tied directly to a fluctuating activity of the domestic industry. Imports would be geared to crude oil demand, the same basis used by leading oil states in setting domestic producing rates.

Because of the tie-in of imports with demand, the new plan emphasizes domestic production during future growth periods. It permits both domestic production and imports to fluctuate in accordance with changing economic requirements on a pre-established basis. This will permit long-range planning by producers, refiners and importers.

The program offers producers hope for a more stable and effective way to control imports. And it likely will require far less revision through the years than the import allocation plan has required since its inception.

The 30-day "study period" offers all segments of the industry and all companies an opportunity to express their views on the proposed new plan. Everyone should take advantage of this invitation.

In doing this, all should be as constructive as possible. Benefits of certain phases should be pointed out along with the defects of other portions of the plan. Most important of all, along with criticism of the defects should come constructive suggestions for improvement.

If all will put their best efforts forward, it is likely that some of the problems can be ironed out. This would enhance the chances of designing the best type of program for the greatest number of interested groups.

It behooves the industry to do its utmost to work out a fairly satisfactory program. This would be better than the frequently cussed and discussed alternative: mandatory government controls.

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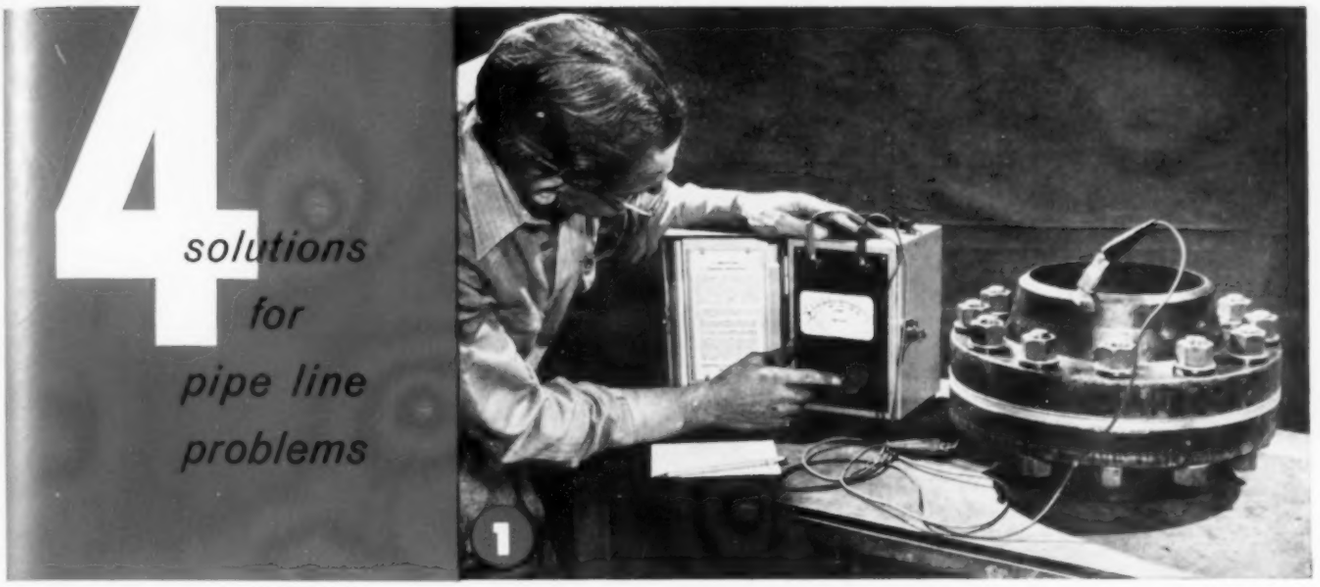
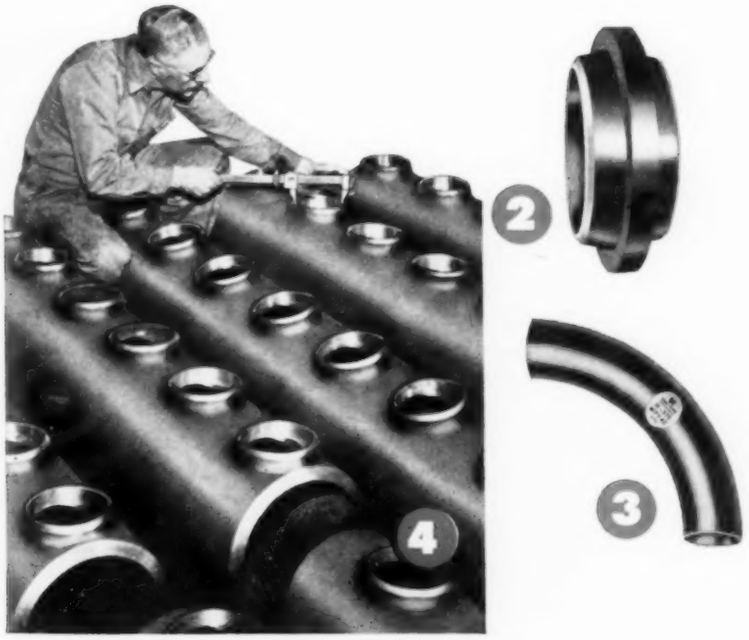


TUBE-TURN® Welding Fittings and Flanges



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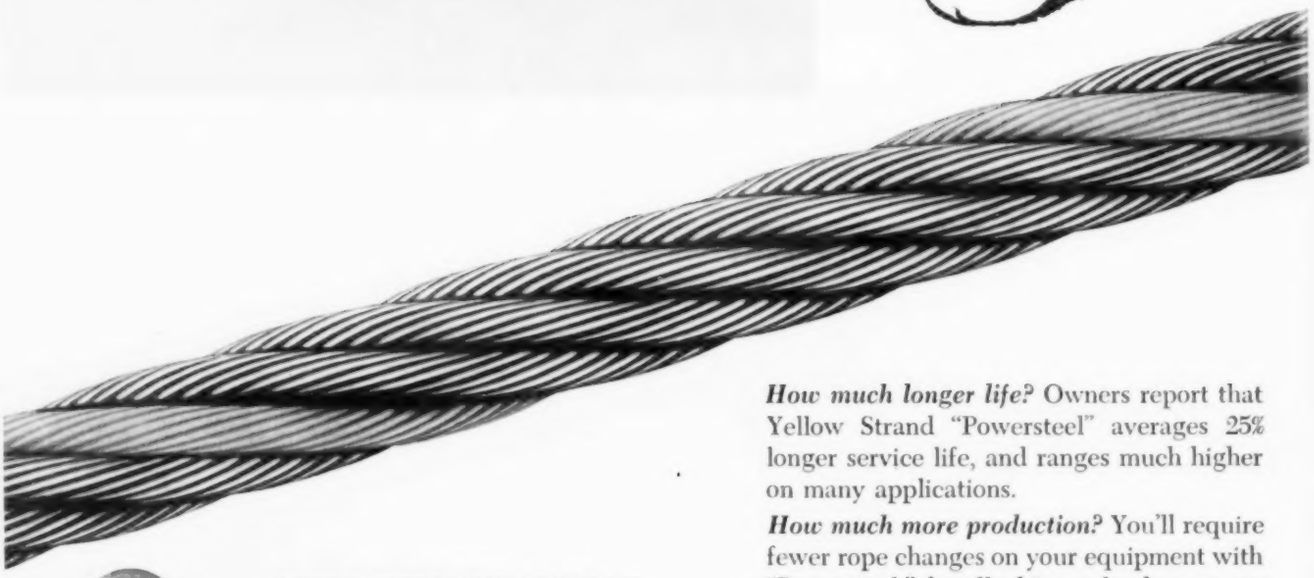

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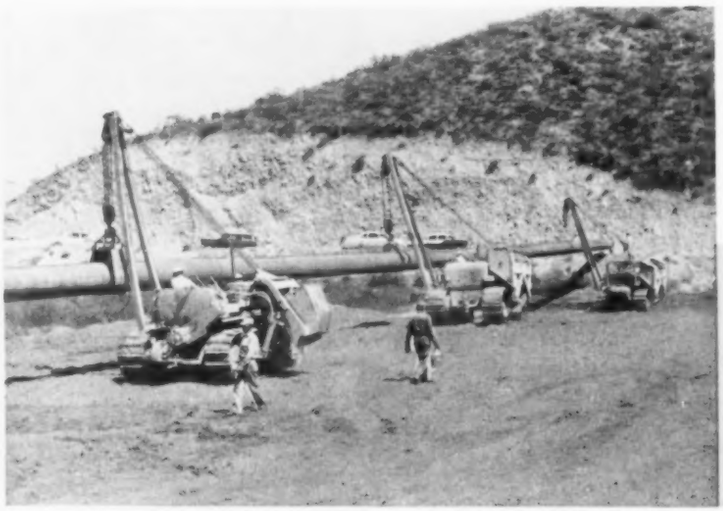

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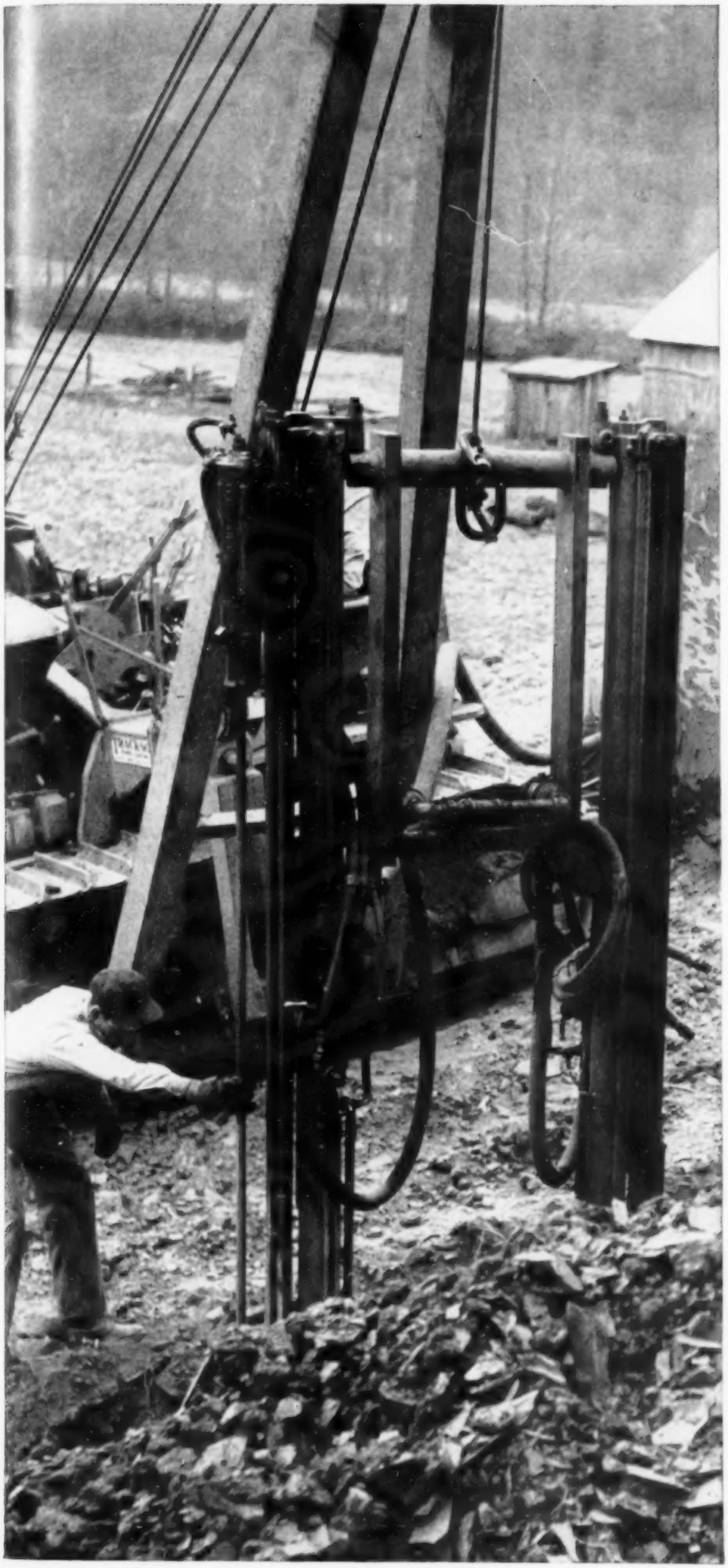

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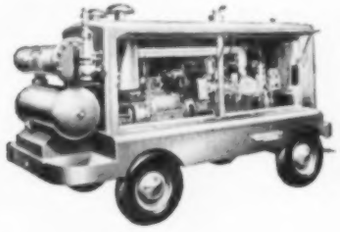

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SPREAD SUPT. GARLAND MIMMS

Cape Construction Co., Flagstaff, Ariz., laid approximately 100 miles of 24" crude oil pipeline in the merciless terrain of the Four Corners area. Under back-breaking conditions, the spread averaged 2½ miles a day. And its Cat Diesel Engines were a big factor.

Says Garland Mimms, spread superintendent, "The fact that 95% of our power is from Caterpillar Diesels shows that we believe in them to get the job done."

Among the engines on the spread were a Cat D318 in a Northwest Shovel, a D315 Twin Arc-Welder, two D8800 Diesels in Cleveland Ditchers, and 22 Cat Diesels in the tractors. They worked 11 hours a day, seven days a week.

Here are powerful, heavy-duty engines designed to produce maximum production at low cost under every conceivable condition. The engine block (see photo below) is an example of Cat design. The block is made of special alloy iron which has a tensile strength more than 50% greater than most other makes. This lowers maintenance costs because it maintains good alignment of moving parts. Bearing caps are mounted in the block, *not* on it, enabling side thrust on the bearings to be absorbed by the block rather than by the studs. This assures true crankshaft alignment extending bearing life. And each block has inspection doors for easy inspection of bearings without dropping the pan.

Wherever the pipe takes you, these modern, heavy-duty Caterpillar Diesels assure you dependability, low operating costs and minimum down time. Your nearby Caterpillar Dealer will show you the exact power for any job from the D311 (65 HP) to the big D397 (650 HP, maximum output capacity). Call him today. And remember to specify Cat power when ordering pipeline construction equipment.

Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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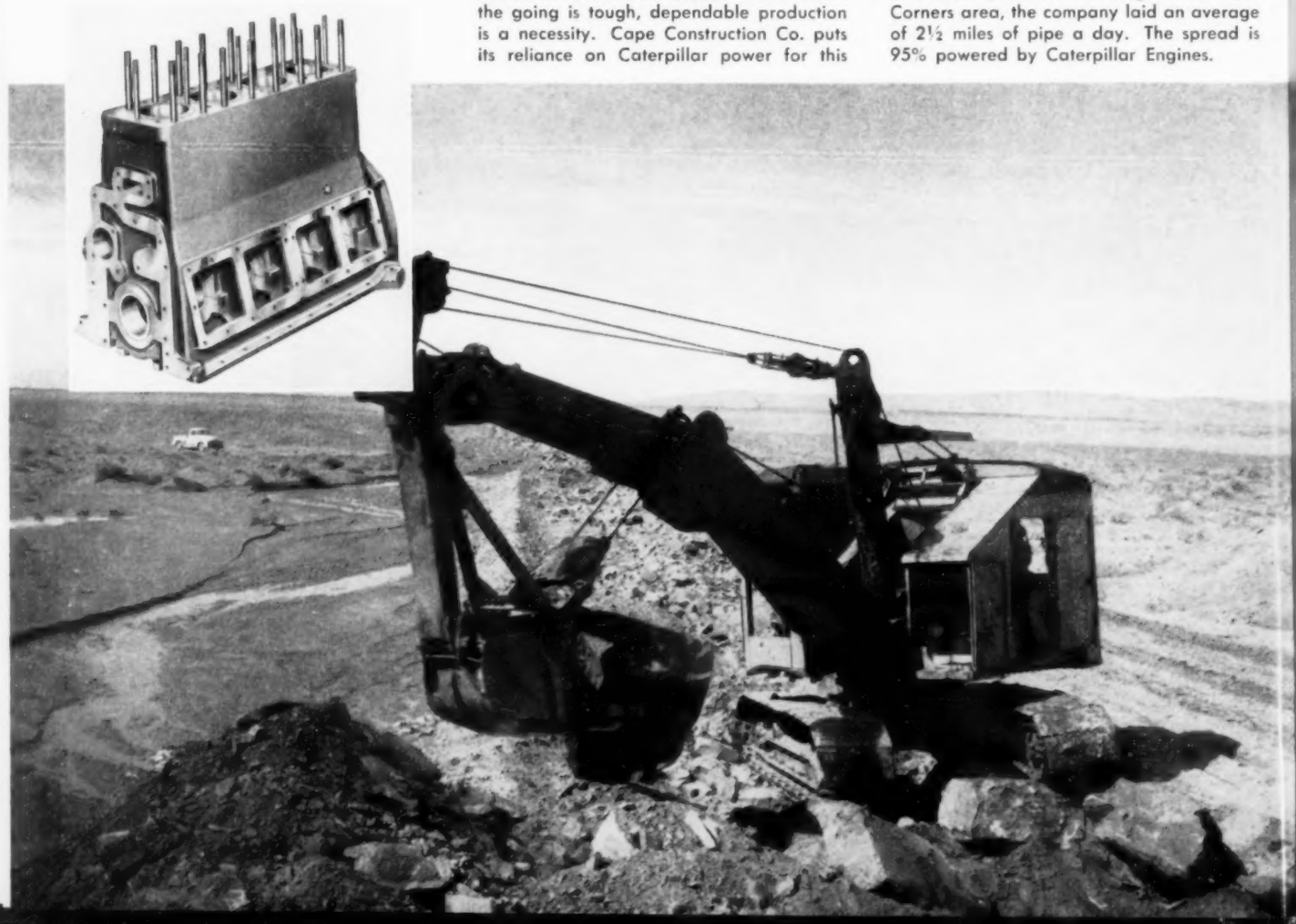
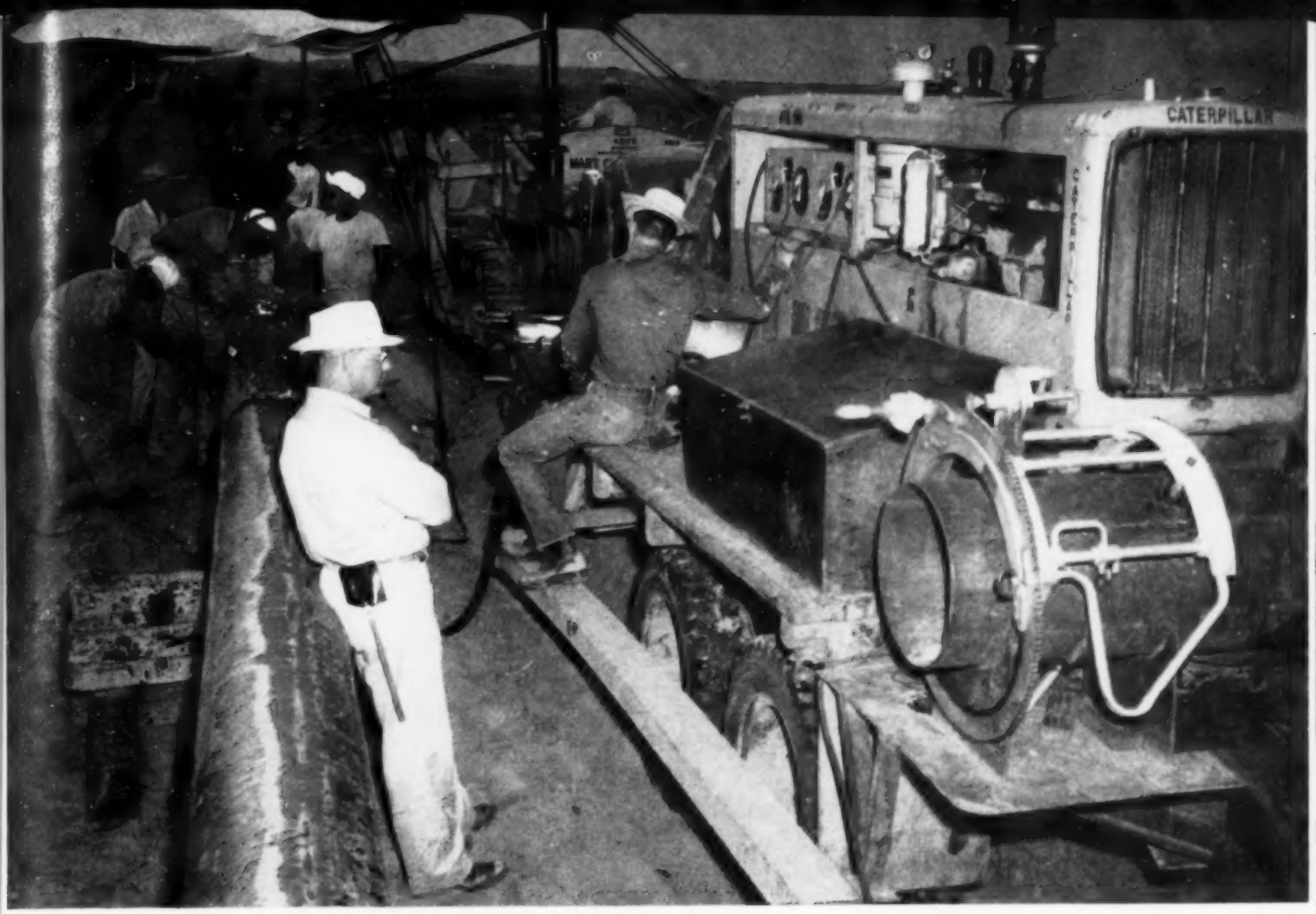


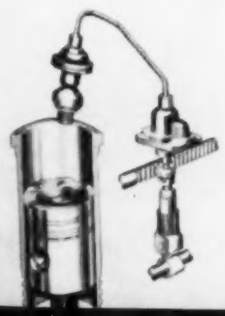
POWER: CAT D318 DIESEL — Out where the going is tough, dependable production is a necessity. Cape Construction Co. puts its reliance on Caterpillar power for this Northwest Backhoe. Starting in the Four Corners area, the company laid an average of 2½ miles of pipe a day. The spread is 95% powered by Caterpillar Engines.



POWER: CAT D315—The Cat D315 Twin Arc-Welder gets the job done, too. This compact, multiple, portable welder is available on a steel skid base or wheels. Two Lincoln welding generators in one compact frame supply 300 amps each with independent job selector and current controls.

POWER: CAT D8800 DIESEL — In this isolated area where there is no margin for inefficiency, both Cleveland ditchers in the job were powered by dependable D8800 Diesels. Unless the ditch is kept ahead of the pipe, a costly stoppage results for the entire spread.

ENGINE POWER BY CATERPILLAR



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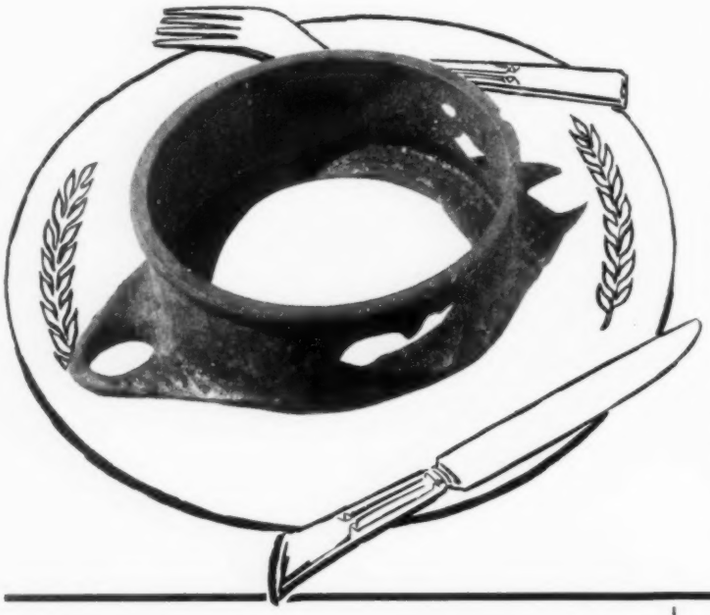

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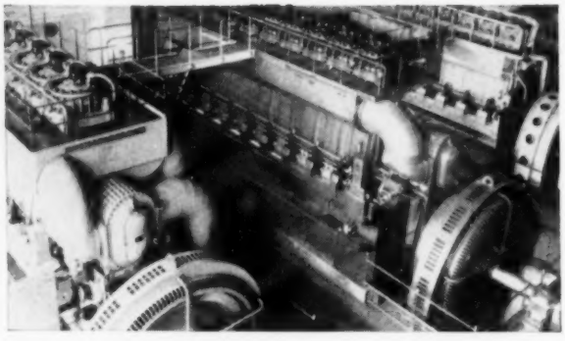

COOK RINGS IN DIESEL SERVICE 3 YEARS—STILL GOING STRONG

Here's a report on Cook rings at Rockville Centre, N. Y. municipal power plant. It's the result of a cylinder inspection on their No. 8 diesel unit after nearly three years of continuous operation.

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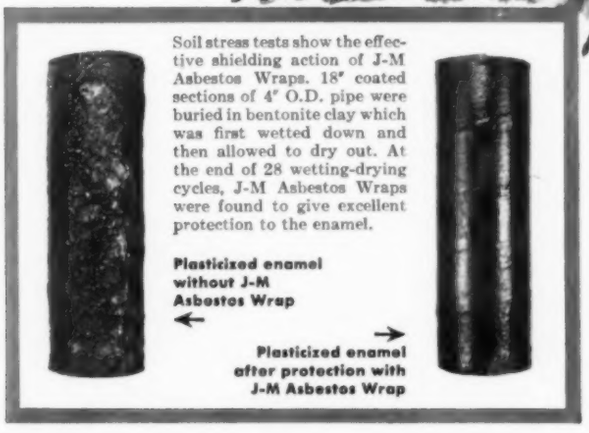

Soil stress tests show the effective shielding action of J-M Asbestos Wraps. 18" coated sections of 4" O.D. pipe were buried in bentonite clay which was first wetted down and then allowed to dry out. At the end of 28 wetting-drying cycles, J-M Asbestos Wraps were found to give excellent protection to the enamel.

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→ **Plasticized enamel after protection with J-M Asbestos Wrap**

Get lasting protection with tough, strong J-M Asbestos Wraps

Extensive research and field tests conducted by a leading firm of consulting engineers have demonstrated the effects of soil movement and earth loads on pipeline enamels. They show how the forces of the soil tend to distort and induce thin spots that weaken the protective coating . . . permit corrosion of the pipeline.

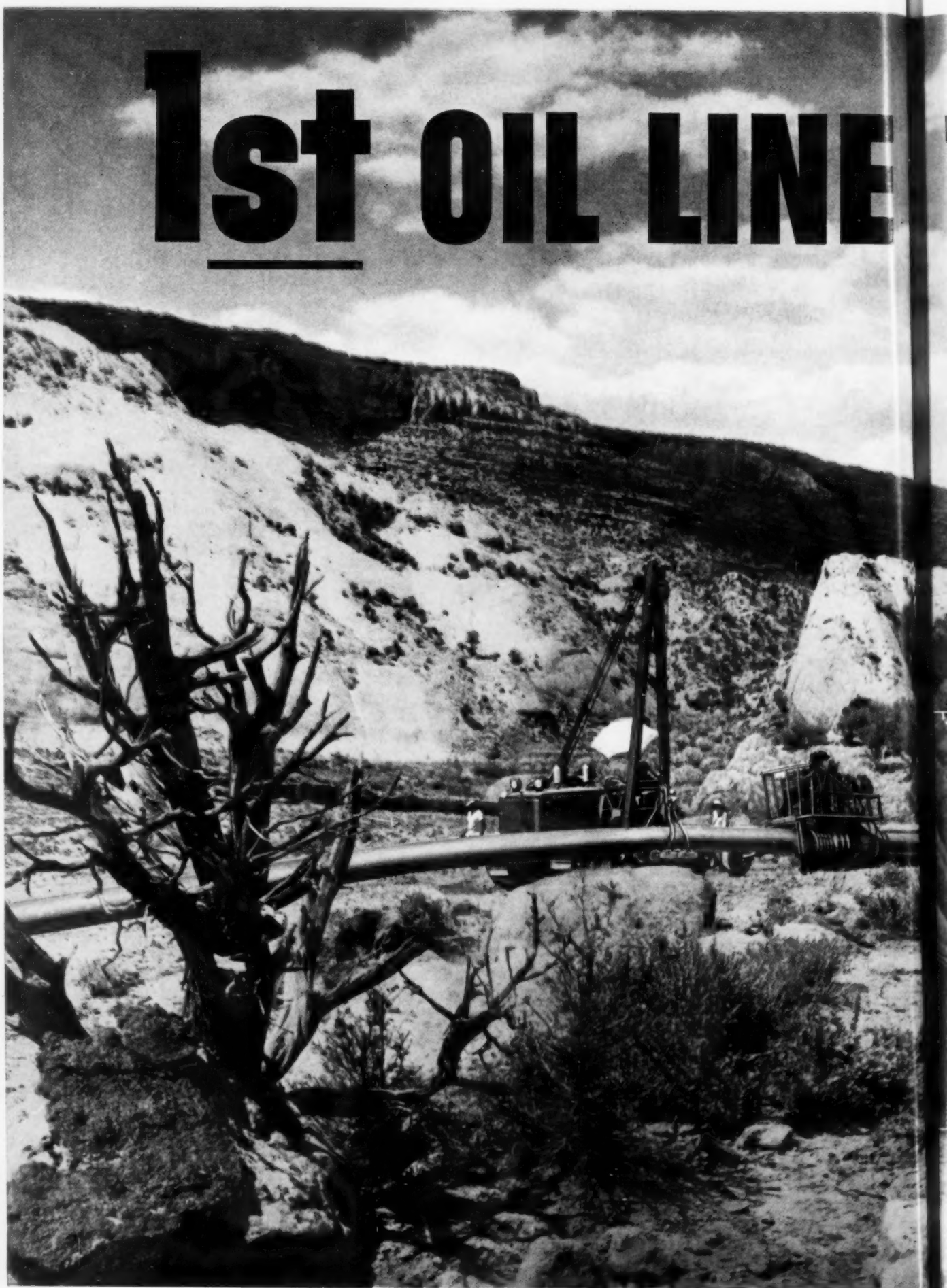
The same research and field tests also demonstrated that J-M Asbestos Wraps provide the strong protection that strong coatings need and deserve. "Asbestos Wraps offer the most effective single protection against damage—prolong the working life of pipeline enamels." Here's why . . .

Asbestos is an ageless mineral. Fibers of asbestos are strong and tough . . . cannot rot or decay. As used in J-M Wraps, the fibers are felted, then impregnated with a coal tar or asphalt saturant to form literally a flexible covering of stone. These "stone-like" qualities form a durable shield—protect pipeline enamels from earth loads and soil movement which weaken coatings and permit pipe corrosion to set in.

Pipeline engineers are invited to write for their own copy of PP-34A, a *3-Point Study of Pipeline Coatings and Wrappers*, at no cost or obligation.

Johns-Manville, Box 14, New York 16, N. Y.
In Canada, Port Credit, Ontario

JOHNS-MANVILLE


1st OIL LINE

TO CALIFORNIA

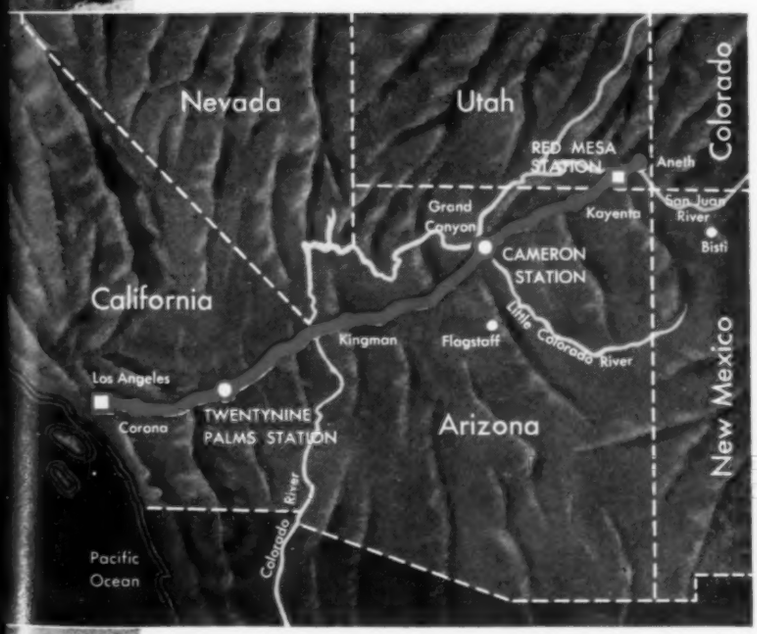
The Four Corners Pipe Line is the first line ever built to supply California refineries with oil from outside the state

Shell Pipe Line Corporation, acting as agent for the Four Corners Pipe Line Company, designed, constructed and will operate this important 16-inch line. The line itself will be owned by six companies — Continental Pipe Line Company . . . Gulf Oil Corporation . . . Richfield Oil Corporation . . . Shell Oil Company . . . Standard Oil Company of California . . . and Superior Oil Company.

The purpose of the line is to tap reserves of 250 to 500 million bbls. to meet anticipated expansion in California's economy.

A. O. Smith furnished more than 600 of the 637 miles of 16-inch main line that runs from Aneth, Utah, to Los Angeles.

For almost 30 years . . . A. O. Smith line pipe has always been manufactured to a high standard of quality . . . precisely controlled at every step of production. That's why A. O. Smith pipe, made and installed in 1928, is still in operation. That's why so much A. O. Smith pipe is found in every important pipeline project.



From Aneth, Utah, to metropolitan Los Angeles, the line surmounts many obstacles. They include—elevations ranging from sea level to 6700 feet . . . deserts . . . three major river crossings . . . 200 miles of solid rock . . . and daily temperatures fluctuating between 40 and 120° F.

Through research A.O. Smith Special ... *. . . a better way*

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HOW KONTOL REMOVED 16 TONS OF SCALE FROM A PIG-CLEANED PIPELINE

This eastern pipeline—a 385 mile 6″ product line—had never been cleaned before. When a cleaning program was finally decided upon, scrapers were used. Numerous scrapers, both brush and knife, were run through sections of the line. For example, 73 sets were run between Pump Stations No. 1 and 2. 10 were run between No. 2 and 3.

After a 5-month scraper program, the line efficiency (as expressed by the "C" factor) increased from 123 to 133—after which it remained constant, despite the use of additional scrapers. When a scraper was used, however, the stream continued to go off-color about 15 minutes before the scraper arrived at the pumping station.

Then Kontol corrosion inhibitor was applied at the rate of one gallon per thousand barrels of throughput. One day later, two scrapers were run through the line. At the scraper trap the stream went off-color thirty minutes before the arrival of the first scraper, and stayed off-color until after the arrival of the second scraper. A second set of scrapers was run 12 days later, with similar results — *definite evidence that Kontol loosened scale previously untouched by the scrapers.*

RESULTS OF KONTOL TREATMENT

Line throughput increased 720 bbls./day.
An estimated 16 tons of scale removed.
Further rusting and scaling arrested.
The need for scraping eliminated.

KPL-58-1

SUMMARY OF "C" FACTOR BEFORE AND AFTER KONTOL
(following use of scrapers)

LINE TREATED	Before KONTOL	After KONTOL
Pump Station No. 2 to 3.....	132	138
Pump Station No. 3 to 4.....	135	142
Pump Station No. 4 to 5.....	138	145
Pump Station No. 8 to 9.....	118	135

TRETOLITE COMPANY
KONTOL
SAINT LOUIS LOS ANGELES

Write for this **FREE KONTOL BULLETIN**

KONTOL 77

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Chemicals and Services for the Petroleum Industry
DEMULSIFICATION • DESALTING • CORROSION INHIBITING • PARAFFIN REMOVAL • SCALE PREVENTION
WATER DE-OILING • INJECTIVITY STIMULATION

ON PIPE LINE SPREADS

THROUGHOUT THE WESTERN HEMISPHERE

From Canada to the Straits of Magellan, more Maloney Pipe Line Products are in use on new construction, and in the operation and maintenance of existing lines, than ever before. Superior quality, produced in the Industry's only plant with completely integrated manufacturing facilities, insures maximum protection of your Pipe Line Investment Dollar. Maloney quality is available throughout the World on short-notice shipping dates — why settle for less?

CROSSING INSULATORS

Maloney Insulators are available in a full range of sizes in steel (rubber insulated) and modern plastics. There is a Maloney Insulator for **any** Pipe Line today, or planned for tomorrow.

SCRAPER CUPS AND DISCS

With a wide variety of rubber compounds for varying service, and superior physical design, Maloney Cups and Discs offer outstanding service in all pigging applications. Widely imitated, but never equaled for long wear.

PIPE LINE SPHERES

A product of Maloney Research and Development. The **new** way to increase the efficiency of Pipe Lines. Product Separation, Hydrostatic Testing, Water and Distillate Removal — all of these and more can be accomplished **better** with Pipe Line Spheres — and at lower cost.

CASING END SEALS

Tough, molded rubber end seals that eliminate the old crossing end seal problems. Zipper types for **tight** replacement service on maintenance jobs. With Maloney Casing Seals, engineering design replaces unnecessary bulk and difficult installation to effect a long life seal.

PUMP AND COMPRESSOR PARTS — THERMOWELLS

Piston Rings, Valve Plates and Discs, Rod Packing — in several types of Micarta for **any** Pipe Line Service. Rod Packing in Cast Iron and Cast Bronze, and Thermowells in various metals — all precision machined for accuracy.

FLANGE INSULATION KITS

Packaged in complete sets for on-the-job use. Maloney Flange Insulation is rated to the flange on which it is installed. No lost components in the field. All types available—raised face and ring-joint.

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For more data on advertised products, use Readers' Service Cards, last page.

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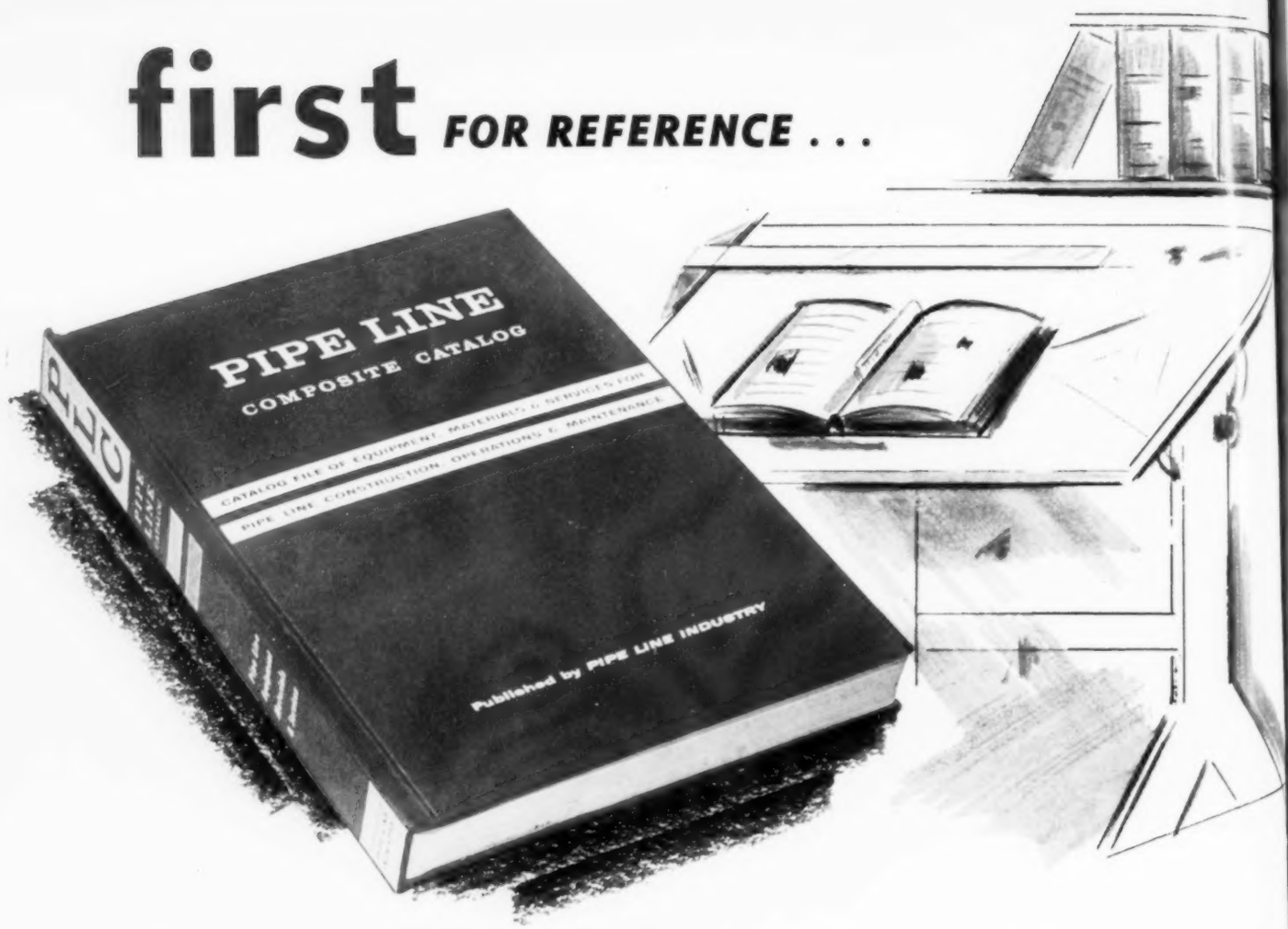
PIPE LINE
COMPOSITE CATALOG
CATALOG FILE OF EQUIPMENT, MATERIALS & SERVICES FOR
PIPE LINE CONSTRUCTION, OPERATIONS & MAINTENANCE
Published by PIPE LINE INDUSTRY

A one-volume reference library for purchasing and specifying. That's the best way to describe the only comprehensive catalog data file published specially for the Pipe Line Industry. Convenient to handle, thoroughly indexed, it is saving time and money for thousands of pipe line men.

first FOR INFORMATION ON MANUFACTURERS AND SERVICE COMPANIES

Included in 147 equipment and service company data in PLCC, there are 1,627 manufacturers' representatives and sources of supply listed.

first FOR INDIVIDUAL EQUIPMENT AND SERVICE ITEMS

There are 11,148 items of equipment and service items cataloged, with detailed information on specifications, installation, operation, maintenance, service—an entire library of useful reference.

first FOR CONSTRUCTION EQUIPMENT AND SERVICE

Pipe Line construction and service items listed in PIPE LINE COMPOSITE CATALOG total 390 . . . an invaluable aid to office and field specifications and purchases.

When you are ready to buy or specify, or if you just want planning information, look first in PIPE LINE COMPOSITE CATALOG.

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Aldrich Pump Co.
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PIPE LINE COMPOSITE CATALOG

Published by PIPE LINE INDUSTRY

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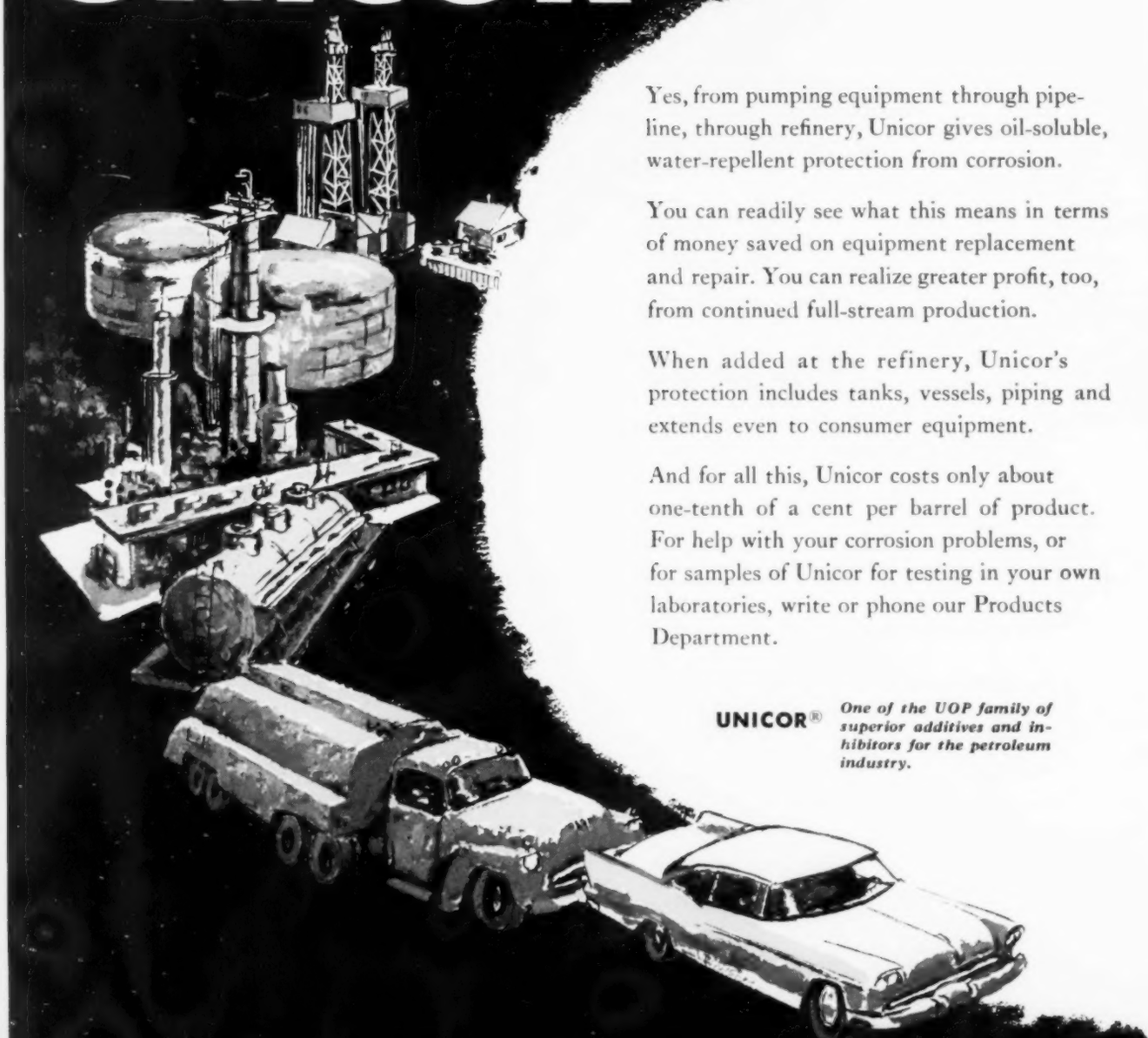


Yes, from pumping equipment through pipeline, through refinery, Unicor gives oil-soluble, water-repellent protection from corrosion.

You can readily see what this means in terms of money saved on equipment replacement and repair. You can realize greater profit, too, from continued full-stream production.

When added at the refinery, Unicor's protection includes tanks, vessels, piping and extends even to consumer equipment.

And for all this, Unicor costs only about one-tenth of a cent per barrel of product. For help with your corrosion problems, or for samples of Unicor for testing in your own laboratories, write or phone our Products Department.

UNICOR® *One of the UOP family of superior additives and inhibitors for the petroleum industry.*

UOP® **UNIVERSAL OIL PRODUCTS COMPANY**
30 Algonquin Road, Des Plaines, Illinois, U. S. A.

19 GASO PUMPS FOR THE Four Corners Pipe Line

The pumps that move the crude from the gathering lines to the main line of the fifty-million dollar Four Corners Pipe Line are GASO Pumps. In all, Gaso has supplied the line with 19 pumps in models to meet the individual requirements at the feeder stations and in the Kingman and Corona pressure reducer stations. Typical feeder station installations:

At Aneth: Figure 2652 Gaso Duplex Piston Power Pump (4″ to 7¼″ x 12″).

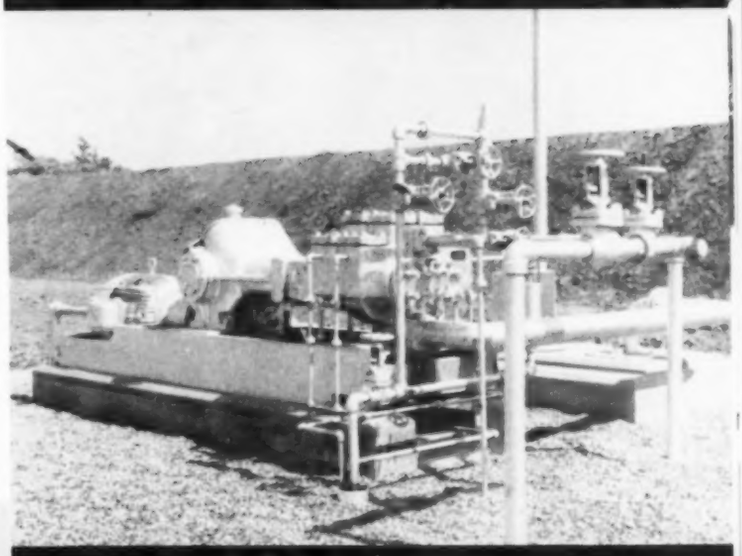
At Arrowhead, Desert Creek, Rice, Little Mesa, Bluff, and East San Juan: Figure 1849 Gaso Duplex Piston Power Pumps (2½″ to 4″ x 10″).

At Ratherford and White Mesa: Figure 1550 Gaso Duplex Piston Power Pumps (2½″ to 5″ x 10″).

At McElmo Creek, Ratherford, San Juan, White Mesa, West Aneth and East Aneth: Figure 1753 Gaso Duplex Piston Power Pumps (4″ to 7½″ x 10″).

The Gaso line includes many types and sizes of duplex piston and triplex plunger pumps with moly-iron, steel, and bronze fluid ends for handling crude oils, petroleum products, and salt waters under a wide range of capacity and pressure requirements. May we send you our latest catalog, just released?

Gaso Fig. 2652 Pump handling approximately 900 barrels per hou at the Corona pressure reducing station of the Four Corners Pip Line. Powered by a 200 HP electric motor, operating at 78 RPM



Another Four Corners installation: Fig. 2249 Gaso Duplex Piston Power Pump operated by 15 HP electric moto

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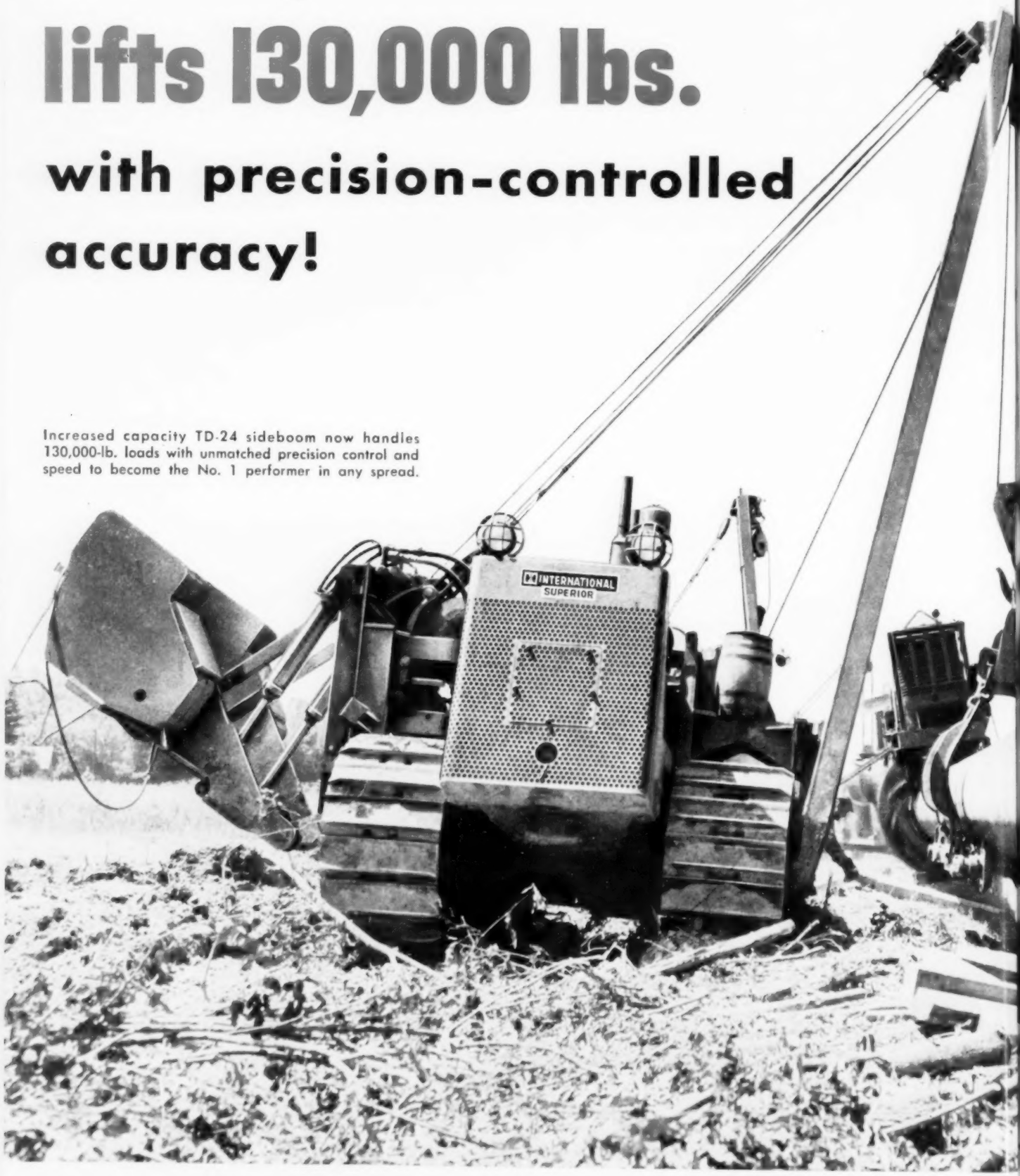
NEW FROM INTERNATIONAL SUPERIOR:

175 dhp TD-24 sideboom lifts 130,000 lbs.

with precision-controlled accuracy!

Increased capacity TD-24 sideboom now handles 130,000-lb. loads with unmatched precision control and speed to become the No. 1 performer in any spread.



New **30,000-lb. maximum lift** at 4-ft. overhang—that's the new International Superior TD-24 Sideboom! Increased lift capacity combined with 175 precision controlled drawbar workpower, make it the nation's No. 1 big-inch boom rig!

The 8% hp. increase is matched by new power train strength to meet "slam-bang" cross-country conditions.

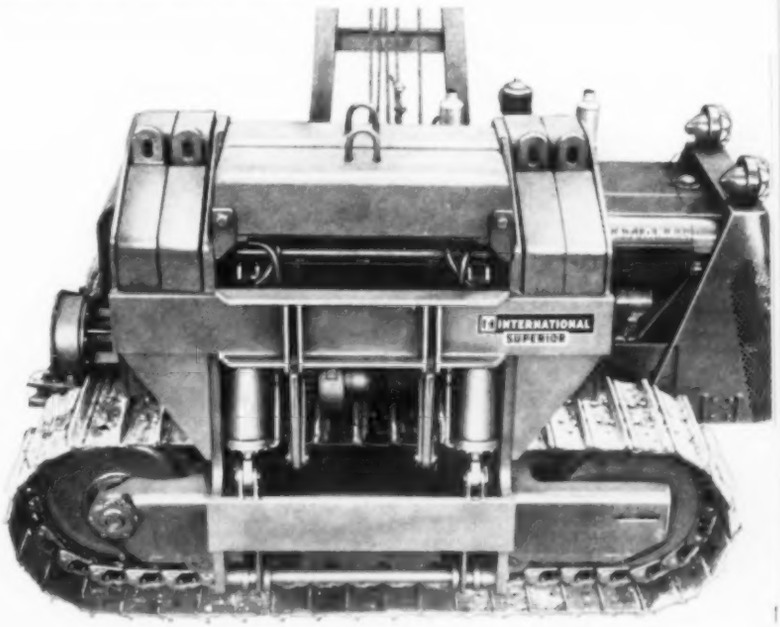
Adding 5,500 pounds of hydraulically controlled counterweights achieves the big 18% increase in lift. And these six exclusive quick-change counterweights also save you up to 90% of time required to weight the sideboom correctly, depending on load and terrain, to speed all on-the-line jobs.

Planet Power steering—mud-beating flotation! Famous TD-24 exclusive mud-and-mountain beating margin of flotation means up to 18% less weight psi on the tracks than other king-size crawlers! Exclusive TD-24 Planet Power steering assures full-time "live" power on both tracks to turn smoothly with heavy boom loads! Torque converter gives steady power.

Exclusive TD-24 fingertip hydraulic braking and foot decelerator give precision pipe-carrying control. Exclusive schedule-beating, on-the-go TD-24 Hi-Lo Planetary shifting gives fingertip matching of speed to load. Exclusive reach-easy controls in vertical cluster, add operator convenience and control accuracy.

Get in the driver's seat—See why the TD-24 sideboom can outwork any other king-size sideboom, anywhere. And see how the new TD-20, or the bonus-powered TD-14 and TD-9 sidebooms also give you top pipe-handling value in their fields. See your International Superior Distributor for a demonstration of the boom and tow equipment you need.

TD-24 bulldozer with 175 dhp stands alone as the top producer in its size class for pioneering and cleanup jobs. Imagine 41,130 pounds of Planet Power-controlled pull at rated rpm under positive load control on turn or straightaway!



Six quick-change pin-locked counterweights with big lifting eyes save up to 90% on time required to adapt rig to any working conditions. Rack retracts well over tracks for outstanding balance and maneuverability.

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INTERNATIONAL®
SUPERIOR

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Up near the Yukon they can't afford control failure delays!

One of the most important and unique events in gas processing is now making history along the West Coast of North America. The processing heart of a vast new system of pipeline operations covering the western United States and Canada has just been completed and is now in operation at Fort St. John in northern British Columbia.

When the choice of controls came to a point of decision, the need for unfailing service led the designers and contractors of the McMahon Refinery to Fisher Valves and Liquid Level Controls and Continental butterfly valves.

The very location of the McMahon Plant in comparative isolation along the Peace River far from the usual service facilities dictated the choice of Fisher and Continental Controls for dependable day after day operation.

McMahon Gas Processing Plant
Fort St. John
British Columbia, Canada

Pacific Petroleums Ltd.
West Coast Transmission Corp.

Designed by
Stearns-Roger Engineering Co., Ltd.
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Capacity
400,000,000
cubic feet per day

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

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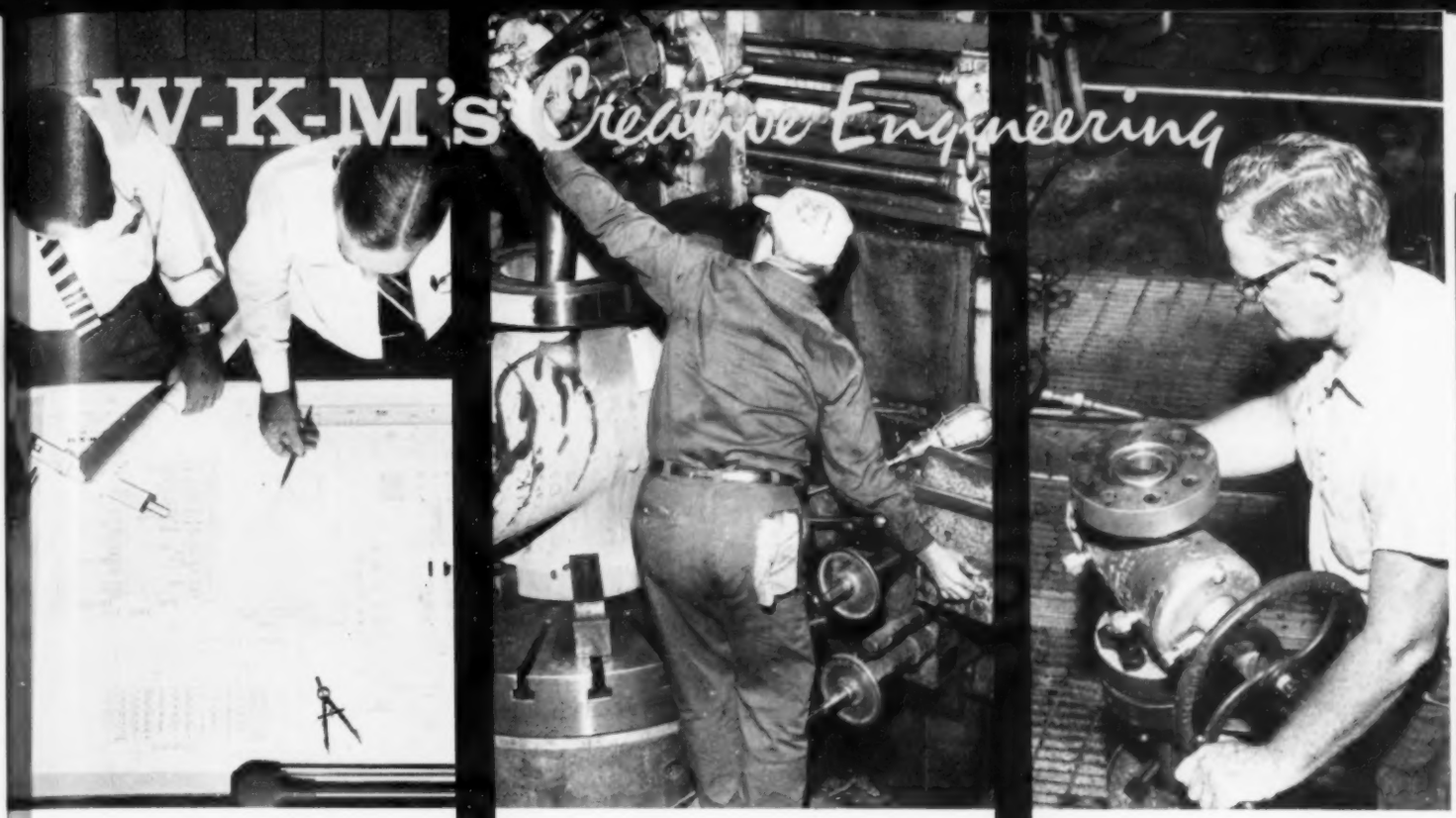
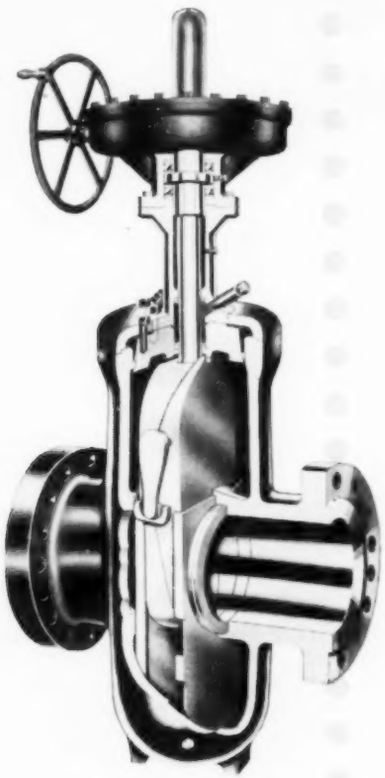


provides the design | the production | the testing

that assure dependable performance



W-K-M ASA Gate Valves

W-K-M's creative engineering is a continuous process that begins with a study of pipeliners' valve problems. It proceeds to design . . . extends through production . . . reaches a climax with the most rigorous testing procedures in the business: Every W-K-M valve passes tests that go far beyond the requirements of your operations.

W-K-M ASA Gate Valves are the best you can use in pipeline service. No other valves compete in design or quality of production.

For performance you can depend on, specify W-K-M when you requisition valves.

W-K-M

DIVISION OF ACF INDUSTRIES
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P. O. BOX 2117, HOUSTON, TEXAS
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Features include: Parallel expanding gates • Through-conduit • Exclusive gate centralizer • Replaceable seats • Pressure seal bonnet • Lubricated seats • Two thrust roller bearings • Super-finished stems.

Design assures: No-surge operation • No turbulence • No pressure drop • Free passage of pigs or scrapers • Easy operation • "On-the-line" overhaul.

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5816

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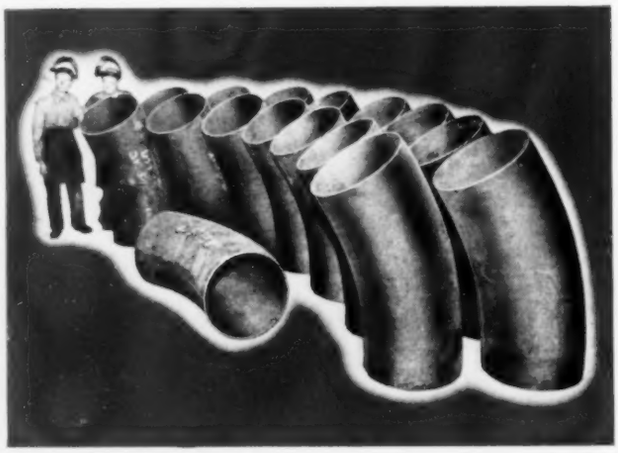
SAVE TIME . . . CUT COSTS . . . SOLVE PROBLEMS



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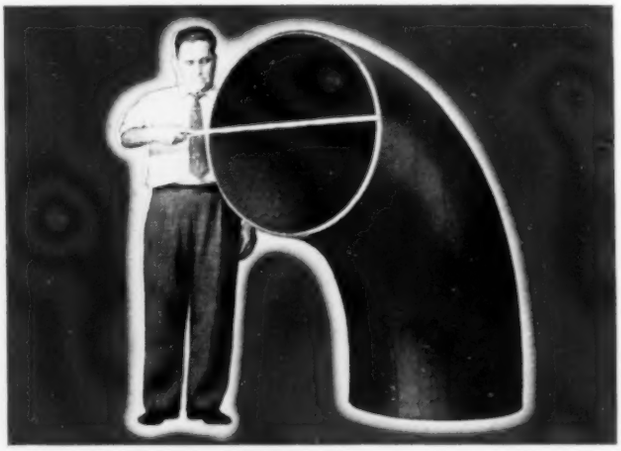
Originated by Midwest and available in 22", 24", 26" and 30" sizes. Angles 10°, 15°, or 30° with 3D radius, providing a long sweep for easy pipe cleaning. 8" tangent at each end removes weld from highly stressed curved section and facilitates alignment. Uniform concentricity permits smaller angles to be obtained by cutting elbow. Available in various wall thicknesses of carbon steel, high yield and low alloy materials. Write for data sheet.

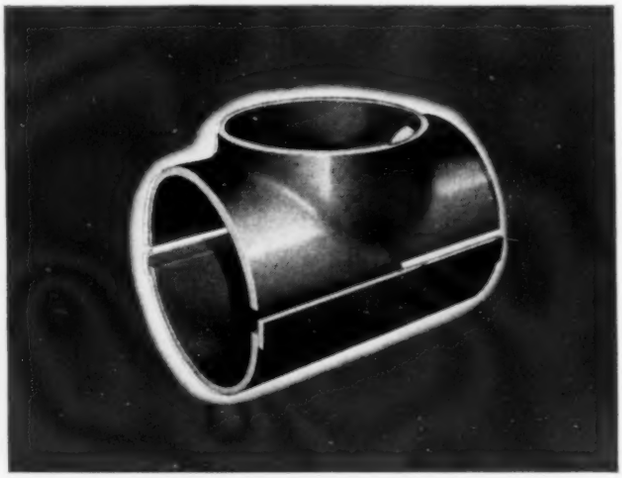


LONG TANGENT ELBOWS

Cost no more than ordinary elbows and are available up to 36" OD in wide variety of materials and wall thicknesses. Tangent at each end equal to ¼ nominal pipe size up to 24" OD—all larger sizes have 6" tangents. These added straight ends save pipe and often eliminate short nipple and extra weld; they remove circumferential welds from point of greatest stress . . . make lining up easier, save time and expense in welding. Write for Catalog 54.

REDUCING ELBOWS

Takes the place of straight elbow and reducer, thus saving one weld, requiring less space and reducing turbulence of flow. Stock sizes available up to 30" OD and in reductions to one-half of large diameter. Being fabricated from plate, it can be made in special thicknesses and materials. Write for data sheets.



WRAP-AROUND SADDLES

"Complete encirclement" type of welded branch reinforcement for making hot taps is available with or without welding strap and from carbon steel or high yield materials. In addition to fitting shown, other types illustrated in Section 8 of ASA B31.1 are available. Write for Data Sheet No. 20.

CAP SADDLES

Reinforcement for nozzle connection into cap. Available in sizes up to 24" on 36" in carbon steel and high yield materials.

Recognizing the fact that conventional welding fittings do not always best meet pipeline needs, Midwest some years ago began the development of special fittings. These are designed for a specific job . . . to save time, cut cost and improve pipelines. The unique Midwest method of manufacture makes the use of special materials easy, economical and permits better delivery . . . it also often enables us to improvise to exactly meet unusual conditions. Write us regarding your requirements.

MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Missouri (P. O. Box 433)
Plants: St. Louis, Clifton, N. J. and Los Angeles
SALES OFFICES: ASHEVILLE (BOX 446, SKYLAND, N. C.) • ATLANTA 9—72 ELEVENTH ST., N. E.
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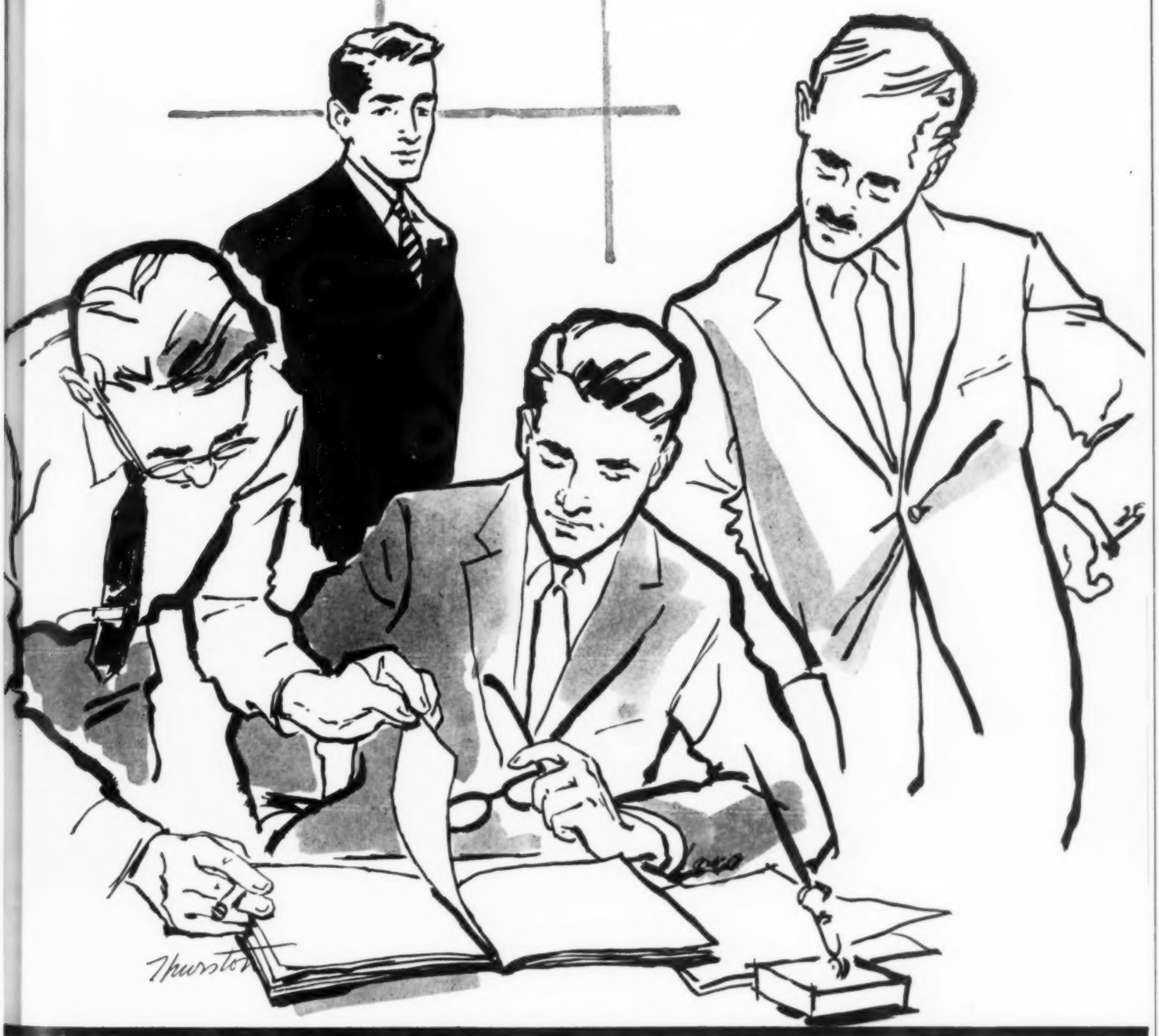
MEMO TO MEN
ON THE WAY UP



WHERE THERE'S BUSINESS ACTION THERE'S A BUSINESSPAPER

Used to be a song, back in the Thirties, titled, *Little Man, You've Had a Busy Day*. Didn't mention the Big Man. But his days are busy, too. He's the man who must make top-level decisions in business. And to make those decisions, he must have facts. All the facts. All the pertinent information he can get.

He finds time, in his busy days, to get that information. How? By getting a major portion of it from one unique source: the business publications serving his particular field.

No businessman, Little or Big, is fully informed until he reads his businesspaper. He reads it for profit, not for pleasure. He searches it through for news of the trade or industry. For facts. For fresh ideas. For new products he can put to work. And he reads the advertising with the same intense concentration he devotes to the editorial pages.

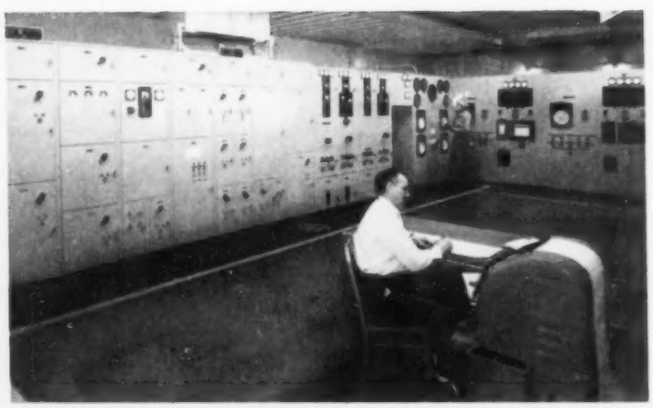
For the man on his way toward becoming a Big Man, his businesspaper is especially important. Take a tip from the reading habits of key men at every level. Take out a subscription of your own. Then, make the time to read every issue—and read it thoroughly.

PIPE LINE INDUSTRY

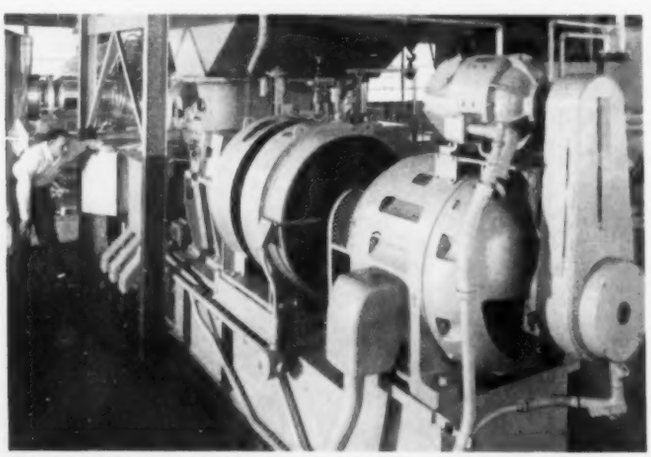
OPERATION upturn
Buy now for extra values
GENERAL ELECTRIC

To keep pace with their increasing customer demands, El Paso Natural Gas Company completes 11th pumping station powered by General Electric gas turbine drives

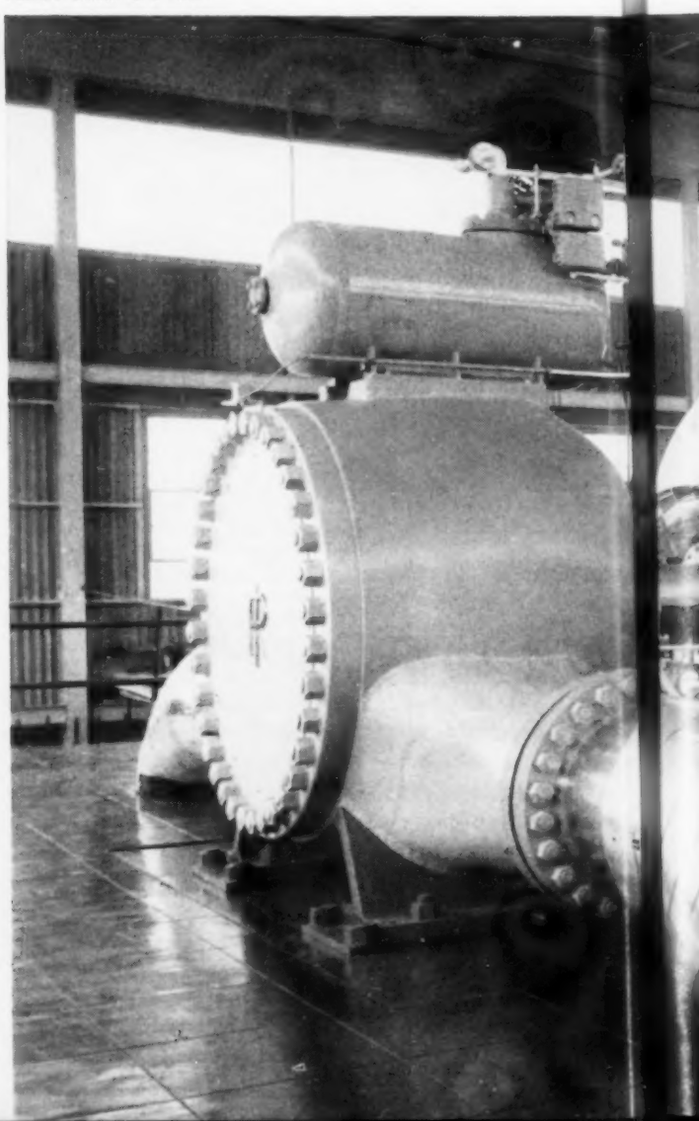
COMPACT GENERAL ELECTRIC GAS TURBINES can provide twice the horsepower of some other prime movers occupying the same floor space. This rotating gas turbine and centrifugal compressor provides smooth, quiet, operation. Installation and maintenance costs are low.



CENTRALIZED Cabinetrol control panels handle practically all auxiliary station functions from one convenient location. Centralized control saves operator time . . . cuts maintenance costs.



DEPENDABLE G-E Tri-Clad* AC Generator provides economical auxiliary power for Belen Station. Improved bearing system gives greater efficiency, longer life, reduced maintenance.



IN 1950, as a part of its continuing expansion program to meet growing demands for gas in the West, El Paso Natural Gas Company began the use of gas turbines for centrifugal compressor drives. The completion of Belen Turbine Station, near Belen, New Mexico, marks a recent step in the realization of their expansion plans.

Belen Station is the 11th EPNG facility to be equipped with General Electric gas turbine drives and centralized control systems. Performance records show that these rugged, compact G-E drives require very little maintenance, and afford substantial floor-space savings.

New, simplified General Electric turbine design eliminates the expense of maintaining a number of auxiliary pumps, blowers and associated equipment. Utilization of either full or semi-automatic control further reduces station operating costs.

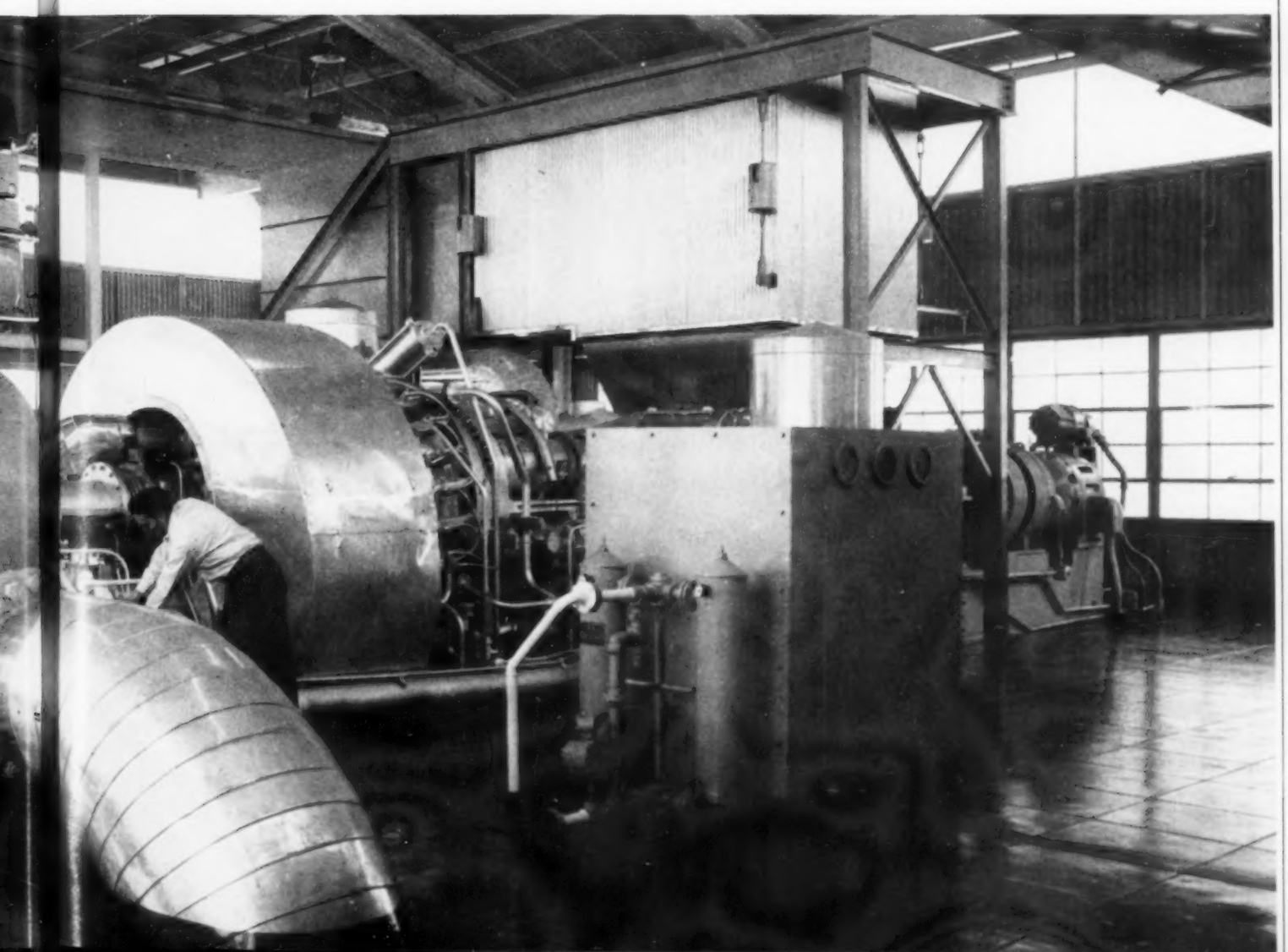
Pre-assembled G-E Cabinetrol* control panels help cut installation costs and centralize operation of auxiliary station functions. Because Cabinetrol control panels can be conveniently located in areas away from operating machinery, no expensive, specially protected equipment is necessary. In addition, the central location of control panels saves operator time and helps provide a neater station appearance.

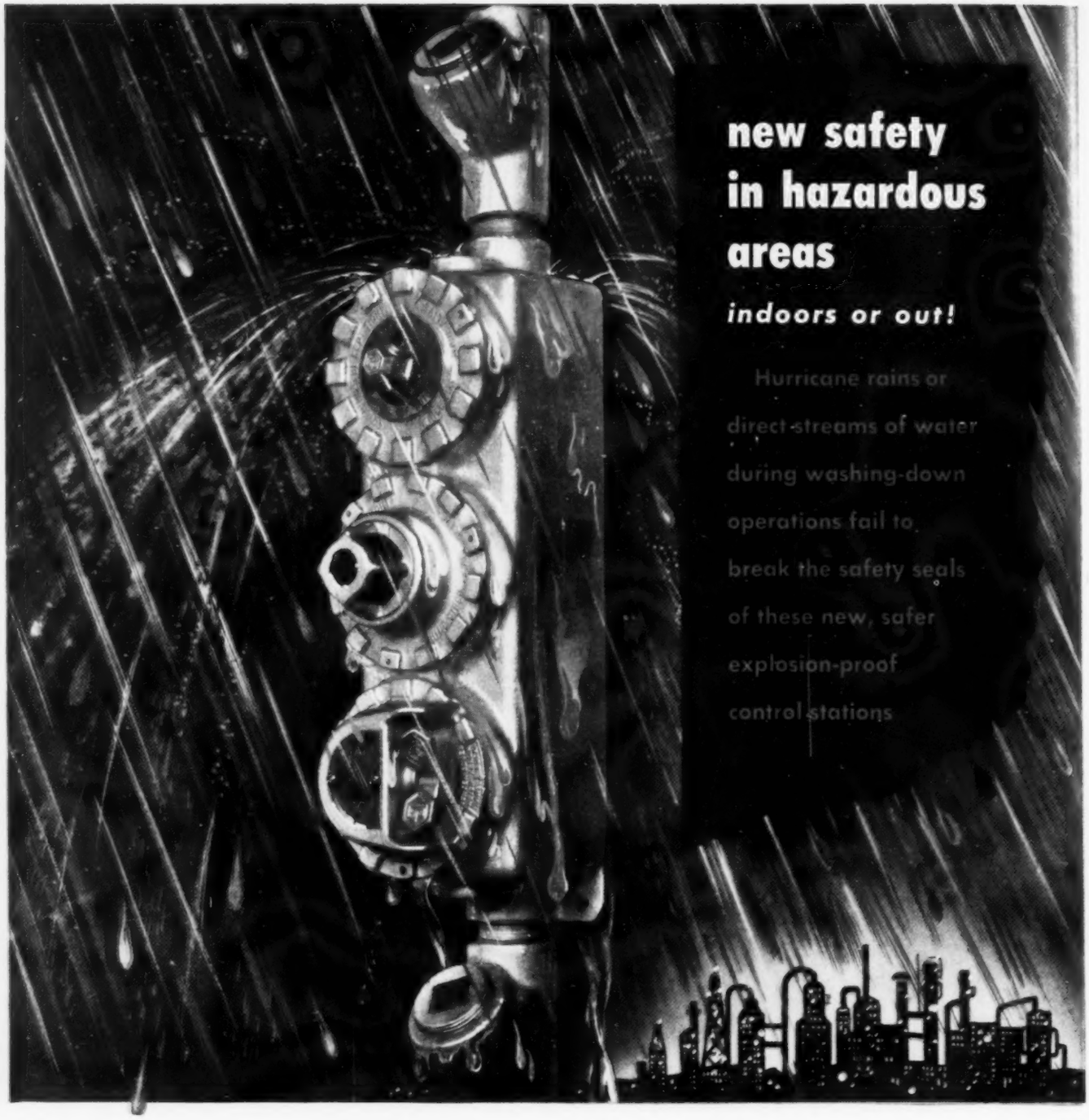
General Electric offers complete engineering service to help you plan the drive system which best meets your gas-pipeline station requirements. Utilization of G-E's experienced system engineering staff can help you get your station in operation faster, with fewer problems, and with less expense. For complete information, contact your nearby General Electric Apparatus Sales Office. For full details on G-E gas turbines, write for free bulletin GED-3546, to General Electric Co., Section 662-51, Schenectady 5, N. Y.

* Reg. Trade-mark of General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC





NEW THREADED-JOINT NEOPRENE-SEALED

Control and Indicating Stations

Explosion-proof, dust-ignition-proof, weather resistant and water-tight (NEMA 4), this new Condulet® EWC series affords safety greater than ever before for pilot lights, heavy-duty push-button stations, selector switches, or various combinations thereof in single, double or triple gangs.

Designed expressly for Class I (Groups C and D) and Class II hazardous areas, the new series features a Feraloy® housing with *threaded* cover and *threaded* operating-shafts throughout. Cover, shaft housing and pilot light jewels are tightly sealed with Neoprene O-rings, effectively shutting out fumes, dusts, all water.

Write direct for descriptive literature and specifications, or contact your Crouse-Hinds distributor

CROUSE HINDS

MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.
Crouse-Hinds Instrument Company, Inc., Silver Spring, Maryland

● CONDULET® ELECTRICAL EQUIPMENT (Explosion-Proof and Conventional) ● FLOODLIGHTING
● TRAFFIC CONTROL SYSTEMS ● AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT ●

These products are sold exclusively through electrical distributors. For application engineering help, contact one of the following offices: Baton Rouge Birmingham Boston Buffalo Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. Salt Lake City St. Louis St. Paul San Francisco Seattle Tulsa Washington **Resident Representatives:** Albany Atlanta Baltimore Charlotte Chattanooga Jacksonville Reading, Pa. Richmond, Va.

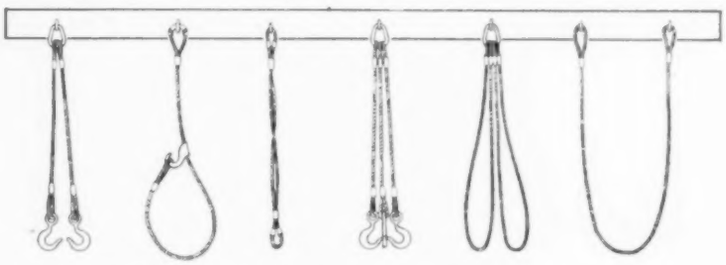
Tuffy® Tips On SAFE USE OF SLINGS AND HOIST LINES

Half of All Workmen's Compensation Cases in Ontario Caused by Materials Handling Accidents

Officials of the Workmen's Compensation Board at Toronto recently reported that 50% of compensation cases in 1956 (excluding accidents in which workmen were struck by something) were caused in materials handling work. Back injuries totaled 16.7% of compensated cases. Medical aid and compensation for back injuries added up to $4,520,000.

That's a high price to pay, in human disability and suffering as well as in dollars, for avoidable accidents. It can be greatly reduced if safe methods of materials handling are more widely adopted and more diligently applied.

Here are some of the things you can do to reduce hazards of faulty equipment and operation:



Safety Begins with "Good Housekeeping"

Too often, slings are dumped in a corner of a storeroom after use. When they're needed again, it's difficult to untangle them and the wrong sling is chosen because it is easiest to get to. Shown here is a rack which makes orderly storage easy. Such tidiness makes for greater efficiency and safety all around.

1. **Keep slings,** ropes, chains, and cables in orderly storage when they're not being used. Such equipment can be damaged between lifts if it is left in haphazard piles.
2. **Don't allow** hitching equipment to remain loose on crane hooks, hoists and loads when not in use.
3. **Check hitching** equipment before using. Inspect it again before return to storage.
4. **Shake out** kinks and twists **to prevent kinked slings** before loading slings. Never use a kinked sling. Remember it is next to impossible to kink a Tuffy Sling in normal use; and when kinks do occur, they can be smoothed out with no serious damage.
5. **Make sure** crane and hoist controls are in best working condition. Test all equipment frequently.

FREE! Tuffy Sling Handbook

Gives complete data on Tuffy Slings — types, dimensions, weights and rate loads. Plus a complete rigger's manual and engineers notebook on wire rope constructions and specifications. Write for your copy now.

You're On the Safe Side With Tuffy® Slings

Maximum safety is one of the many benefits you get in Tuffy Slings. Here are some of the reasons why:

Pressed-On Streamlined Ferrules

Tuffy's pressed-on ferrule gives the tucked eye splice 100% of fabric strength. Applied under great pressure, the steel ferrule literally flows into spaces between wires and strands, developing friction force equal to full fabric strength. Streamlining eliminates snags and projections that might injure hands.

Tuffy's Exclusive Fabric

Only Tuffy gives you the exclusive, patented, machine-braided fabric that combines extra strength and flexibility never before built into any sling. It makes knotting and kinking next to impossible, and if kinks do occur they are easily smoothed out.

Your Tuffy Distributor Will Help You Save Money

He's stocked to give you fast delivery on Tuffy Slings, Hoist Line and other Union Wire Rope. The longer life and greater safety of Tuffy can reduce your operating costs. Get in touch with your Tuffy distributor now.

union Wire Rope **corporation**

SUBSIDIARY ARMCO STEEL CORPORATION

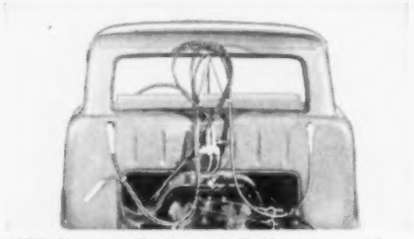
Specialists in high carbon wire, wire rope, braided wire fabric, stress relieved wire and strand

2278 Manchester Ave. **Kansas City 26, Missouri**

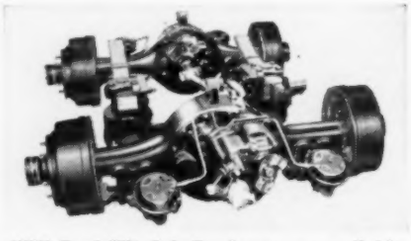
Whatever the job . . . wherever you do it!

There's more to look for in Ford's extra heavies for '59

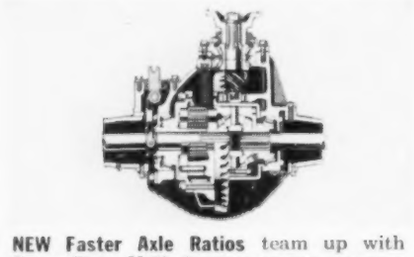
Ford Extra Heavies have proved themselves on every kind of job—you can count on them for *dependability* and *durability*. And in '59, you get high performance at low Ford prices for brand-new reasons! New faster rear axle ratios, new higher capacity axles, and other important options make big-truck operation still thriftier in '59 when you go *Ford*-ward. Send coupon for full information!



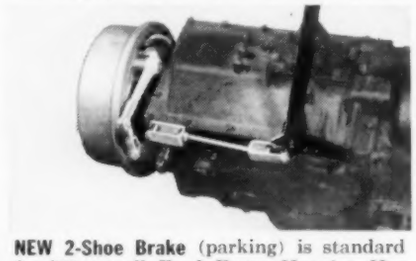
NEW Tractor Equipment Package provides complete trailer air brake and electrical connections, meets I.C.C. requirements.



NEW Ford Tilt Cab Tandems are available with three tandem-axle capacities: 28, 34, and 38,000 lb. Front axles to 15,000 lb.



NEW Faster Axle Ratios team up with Super Duty V-8's for greater gas economy and reduced engine wear. For example, 5.43/7.39 to 1 available in 1100 Series.



NEW 2-Shoe Brake (parking) is standard for '59 on all Ford Extra Heavies. Has 50% greater stopping and holding power, requires 50% less effort to operate.

Tilt Cab Tandem Ford C-950 (above) has hydraulic loader with push-button remote control.

Go *FORD-WARD* for savings **FORD TRUCKS**

FREE—COMPLETE FACTS ON NEW EXTRA HEAVY DUTY TRUCKS
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FORD Division of FORD MOTOR COMPANY
P.O. Box 658, Dearborn, Michigan

☐ **Extra Heavy Duty Conventional and Tilt Cab Trucks**
Up to 36,000-lb. GVW, 65,000-lb. GCW

☐ **Tandem Axle Models**
Up to 51,000-lb. GVW, 75,000-lb. GCW

Name _____

Address _____

City _____ State _____

BRAND-NEW TILT CAB TANDEM FORDS for '59 combine the easier, more economical maintenance of tilts with high tandem-axle load capacities. Tilt design also permits higher front axle loads, longer body on given wheelbase. C-950 Tandem, above, operated by Fairlawn Supply and Concrete, Akron, has 15,000-lb. front axle, 34,000-lb. rear. Carries up to 6,500 brick, compared to 5,000 on a conventional tandem. Has 401-cu. in. V-8, 5-spd. main transmission, 3-spd. auxiliary, 201-in. wb. GCW (with pup trailer) 72,000 lb.

COST LESS ... *less to own ... less to run ... last longer, too!*

For more data on advertised products, use Readers' Service Cards, last page.

NO COMPROMISE WITH QUALITY

in Flexitallic Spiral-Wound Gaskets

There are shorter ways — quicker ways — to make gaskets, but there's only one Flexitallic way.

Each Flexitallic Spiral-Wound Gasket is made to meet a specific sealing requirement. The flange design and the bolt load determine the density of the gasket — compression response is directly related to service. And then, with the most exacting mechanical controls, each Flexitallic Gasket conforms to specification.

Result: the right gasket for the right flange, to make the proper seal.

In the severest service — thermal and physical shock, corrosion, vibration, and unpredictable joint stresses — the Flexitallic Spiral-Wound construction compresses like a spring and then rebounds when the bolt load is relaxed.

For genuine Flexitallic Gaskets, look for Flexitallic Blue—the blue dye in the Canadian asbestos filler. It identifies the Spiral-Wound construction pioneered by Flexitallic in 1912.

FLEXITALLIC GASKET CO.
8th & Bailey Sts. Camden 2, N. J.

Flexitallic®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Flexitallic is a registered tradename. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue* — it's our exclusive blue-dyed Canadian asbestos filler.

C. E. Williams, Gulf Sales Engineer, Midland, Texas, and G. W. Ramsey, Assistant Plant Superintendent, inspect force feed lubricators on one of the modern gas engines at the Goldsmith plant of El Paso Natural Gas Company.

No lubrication problems in 8 years of operation

Since 1949, twenty-seven gas engine-compressor units developing 39,985 horsepower at the Goldsmith plant of El Paso Natural Gas Company have been thriving on Gulf Security Oil. Bearing, ring and cylinder wear maintenance records have been excellent.

Insure safe, more effective lubrication protection for *your* compressor units. Specify Gulf Security . . . the high quality, straight mineral oil. For full information, call your nearest Gulf office.

GULF®

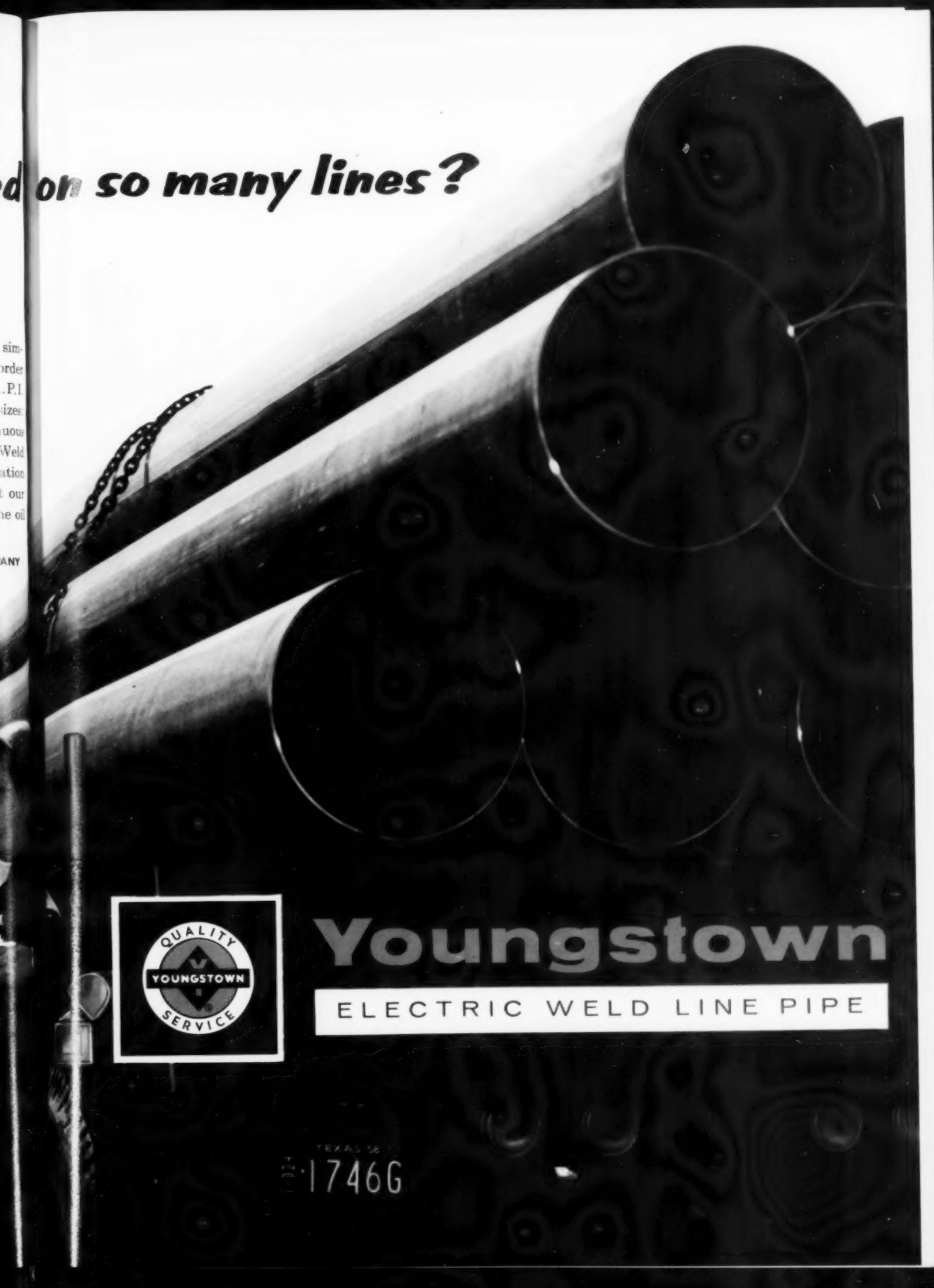
GULF OIL CORPORATION, Dept. DM, Gulf Building, Pittsburgh 30, Pa.

Why is this Youngstown pipe used on

All Youngstown Line Pipe is given a thorough final visual inspection before shipment. Trained inspectors carefully examine the pipe for possible imperfections which might interfere with its field performance. Every length is inspected for dimensional accuracy. That's one more reason why Youngstown pipe can be found on so many lines.

Because Youngstown Line Pipe helps simplify and speed up the job. You can order Youngstown Line Pipe in high test A.P.I. weights and grades . . . and in these sizes: Seamless—2⅜″ to 14″ O.D., Continuous Weld—⅛″ to 4½″ O.D., and Electric Weld—6⅝″ to 22″ O.D. For more information about Youngstown Line Pipe contact our sales and service offices throughout the oil and gas-producing country.

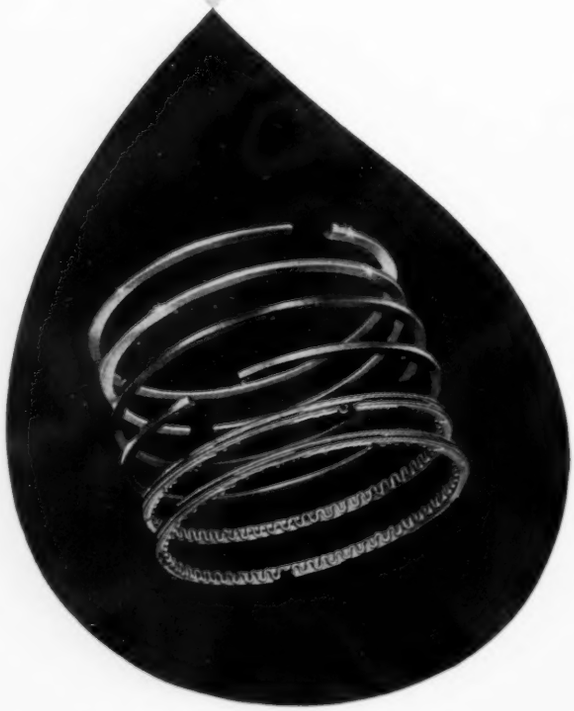
THE YOUNGSTOWN SHEET AND TUBE COMPANY
Youngstown 1, Ohio


d on so many lines?
QUALITY
YOUNGSTOWN
SERVICE
Youngstown
ELECTRIC WELD LINE PIPE
TEXAS 58
1746G

why "Precisioneered"

PEDRICK PISTON RING SETS

Improve Diesel and Gas Engine Performance!



PEDRICK Piston Ring Sets for diesel and gas engines are "precisioneered" to assure maximum power with minimum oil consumption, to most effectively seal against blow-by, to deliver the greatest number of hours of efficient performance at lowest operational and maintenance costs.

The rings in a PEDRICK "Precisioneered" Set are individually designed to assure users coordinated *team* action. The assembled set is tailor-made for *unitized* action in the specific engine.

That's why PEDRICK Engineered Sets are used as original equipment in practically all leading heavy-duty diesel and gas engines . . . and why when replacement rings are installed, PEDRICK Engineered Sets are specified by most maintenance men.

Complete Sets . . . or open-stock rings, you get improved performance, more economical operation when you specify PEDRICK Piston Rings. And remember, if you have any kind of a ring problem, you can count on us to help you solve it. Write, wire or phone: WILKENING MANUFACTURING COMPANY, Philadelphia 42, Pa. SAratoga 9-3770. In Canada: Wilkening Manufacturing Co. (Canada) Ltd., Toronto 2.

Pedrick **PISTON RINGS**

PEDRICK PIONEERED Conformable RINGS FOR BIG BORE ENGINES

PIPE LINE PANORAMA

More Contracts Let on Cross-Country Gas Lines . . . Last half construction continues to set a fast pace. Recent work let by Transco on its $167 million expansion program will add 643 miles of main line loop, laterals and gathering lines to Texas-New York system. Contractors include Bechtel Corp.; Sharman, Allen, Gay, and Taylor; Panama-Williams; J. P. Neill & Company, H. C. Price; Brown and Root; and Hallmac Construction. Work is scheduled for December completion.

Spreads will kick off this month on Coastal Transmission Corp.'s gas line from McAllen, Texas, to Baton Rouge. Oklahoma Contracting has 274 miles in Texas and Louisiana. Coastal and Houston, Texas Gas & Oil Corp. are moving ahead on $185 million gas line to serve Florida markets.

New Type Deep Ground Bed Shows Promise . . . Interstate Oil Pipe Line has successfully field tested new deep ground bed for use in high resistance soils (See Page 40). Graphite rods and coke-breeze backfill are installed to depths of 250 feet, giving life expectancy of 20 years or more—a decided improvement over most conventional ground beds.

Steel casing makes it possible to provide anode string with proper backfill. Outside of casing acts as anode until it disintegrates leaving the graphite rods and backfill to distribute cathodic protection current.

Computers Can Save You Money . . . By providing data that was previously impossible to obtain, medium sized computers are now making it possible to compare different types of compressor engines according to load conditions, compressing capability and parts usage (See Page 55). Tennessee Gas Transmission reports operating controls of performance and maintenance of more than 500 compressor engines have been made more effective through computer analysis.

Transportation "Forums" Pay Off . . . Service Pipe Line President J. L. Burke reports that cooperation and statesmanship of transportation leaders resulted in "remarkable and constructive" action by 85th Congress.

Burke explained that in past years constant bickering between carriers resulted in congressional stalemate on their problems. In recent months a more cooperative approach has been taken. Forums have been set up among all carrier groups to discuss and obtain recommendations on common legislative problems. Thus, in last session congressional leaders received cooperative views of all carriers and shippers in one neat package, rather than being besieged with separate views from various groups as before.

Washington Pipe Line . . . "Midwestern" case may be up for major decision soon—Presiding F.P.C. Examiner Hall requested nine pipe line companies to file answers or objections by September 25. Ruling is yet to be made on Midwestern Pipe Line's proposals which would include imports of up to 204 million cubic feet of natural gas per day from Canada . . . **Possible merger of Pacific Northwest and El Paso Natural Gas** is still under hot debate in F.P.C. Six states favor, but California is holding out—says it "has no wish to be made solely dependent on a single supplier . . ." **Chances are growing slim** for new natural gas bill as favorable as Harris measure to be considered in next session of Congress . . . **Natural gas pipe lines** will increase efforts to up rate of return from present 6 percent to 7.5 percent.

How Interstate uses . . .

Deep Groundbeds for Line Protection

Use of graphite anodes with coke breeze backfill for deep groundbeds provides longer life than scrap steel

By Robert L. Bullock, Technical Services Section Head
Interstate Oil Pipe Line Company, Shreveport, La.

DEEP GROUNDBEDS have allowed Interstate Oil Pipe Line to economically protect bare pipe lines in high resistant soils. Previous experience with rectifiers using normal surface groundbeds, vertical graphite rods with coke breeze backfill spaced 10 to 20 feet apart, proved very costly and unsatisfactory in the high resistant soil of central and southwestern Mississippi. Severe underground corrosion in this area made it necessary to use cathodic protection. Search for pockets of low resistant soil was unsuccessful, but did reveal one location with low resistance below a stratum of high resistant soil. Installation of a single vertical steel groundbed, deep enough to penetrate into the deep zone was successful.

Although deep steel groundbeds were successful, their short life expectancy (6 to 7 years) made the maintenance of cathodic protection costly. Development of a deep graphite coke-breeze backfill groundbed with a life expectancy of 20 or more years has removed this disadvantage. Installing a steel casing makes it possible to provide the anode string with proper backfill. The steel casing serves as the anode until it disintegrates leaving the graphite rods and backfill to continue as the anode.

Design of Graphite Anodes. A number of new problems had to be overcome and experience of others was limited. Since repairs to such a groundbed would be almost impossible, the importance of proper design was paramount.

Any reduction in the length of the groundbed would reduce its effectiveness. Joining the individual graphite rods was given special attention, since a break in the string of rods due to faulty joint design might cause the loss of a portion of the string of rods. Also, water penetrating the rods at the joints might cause concentrated attack and failure.

Based on the experience of others and the recommendation of an anode manufacturer, a custom-built anode was used. A special resin base cement sealing agent, compatible with the characteristics of graphite, was furnished for making up the joints in the field.

Casing Allows Proper Backfill. Experience on normal graphite groundbeds had shown severe necking of graphite rods where soil penetrated the coke backfill. To isolate the graphite rods from the soil the 250-

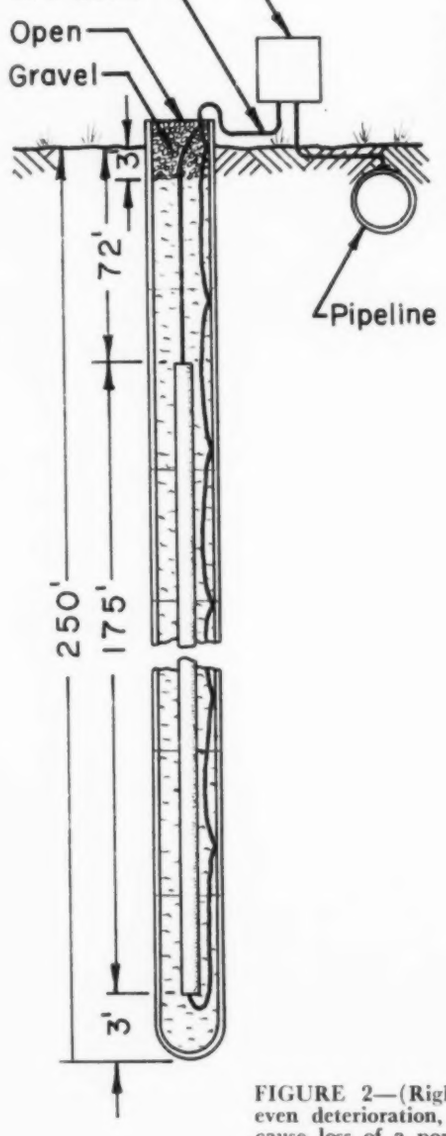


FIGURE 1—(Left) Installing the graphite rods in a steel casing makes it possible to provide the proper backfill. Anode consists of thirty-five 3-inch by 60-inch graphite rods. A continuous insulated wire connected to every joint of casing and to the bottom and top graphite rods insures continuity, even if the casing separates due to concentrated current drainage. Using a minimum 1-inch diameter coke breeze protects the installation from gas blocking by allowing any gas formed to migrate to the surface.

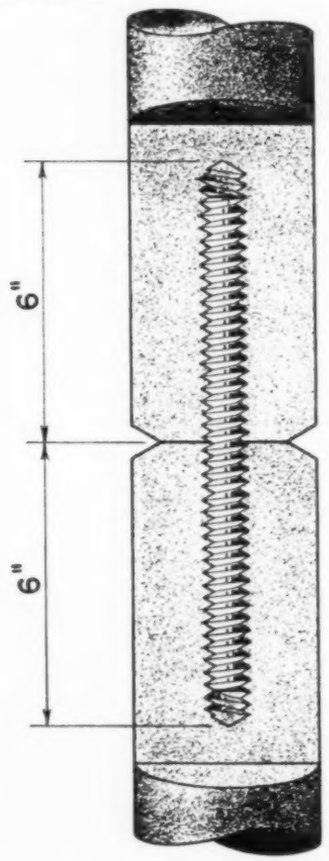


FIGURE 2—(Right) Custom designed anodes insure even deterioration, since a break in the string of rods cause loss of a portion of string. Rods were assembled into sets of three rods each in the field on location, fastened with studs and sealed with a special resin cement.

foot hole was cased. Metal casing in the form of old 8⅝-inch pipe with the graphite rods and coke breeze installed in a step-by-step, joint-by-joint method was adopted after a number of packaging ideas were discarded.

Uniform Casing Deterioration Necessary. Using casing made it necessary to maintain metal-to-metal continuity in the casing in order to insure uniform and complete disintegration of the casing. Since the graphite rods and coke breeze would be shielded from operating as an anode by any portion of the casing not consumed, it was important that the corrosion rate of the casing be uniform and complete. Expected life of the casing would depend on the current output of the rectifier; for a 250-foot string of 28-pound casing, from 11.6 years for 30 amperes to 5.8 years for a 60-ampere rectifier.

Past experience with scrap pipe horizontal and vertical groundbeds and deep metal groundbeds was helpful in adopting the plans shown in Figure 1 for connecting a continuous insulated wire to every joint of casing and to the bottom and top graphite rods. The insulated wire would insure continuity, even if the casing experienced separation due to concentrated current drainage.

Backfill Grain Size Specified. Gas blocking, or the trapping of gas formed at the outer surface of a groundbed, is usually caused by operating a groundbed at excessive current density drainage. Since the proposed deep groundbed would be operated at a very low current drainage, excessive gassing was not anticipated. However, any gas formed would have to be absorbed by the soil or escape up the column of coke breeze. In order to obtain more favorable conditions for the gas to escape and at the same time not defeat the purpose of the backfill, the coke breeze was specified to be not larger than 1-inch diameter and not smaller than ½-inch diameter.

How to Install the Groundbed. After the materials are properly assembled on location and the hole is completed, the groundbed is installed

FIGURE 3—To isolate the graphite rods from the soil and make it possible to backfill with coke breeze, the hole was cased. Casing with graphite rods and coke breeze were installed in a step-by-step, joint-by-joint method. As each joint of casing was installed the rods protruded 6 inches above the casing.

FIGURE 4—After each set of three graphite rods is attached to the previous set, a 15-foot joint of casing is lowered over the rods into place. Maximum casing length that can be handled is 20 feet. Experience, however, showed faster progress with 15 foot joints. All joints except the bottom joint, which was 18 feet, were 15 feet long.

FIGURE 5—Number 6 wire is fed through each joint of casing and bonded to the previous joint. The casing is then lowered and welded to the joint already in the hole. The welded string of casing is then lowered into the hole. Coke breeze is added to fill the annulus between the rod and the casing. Weight is added by filling the casing with water.

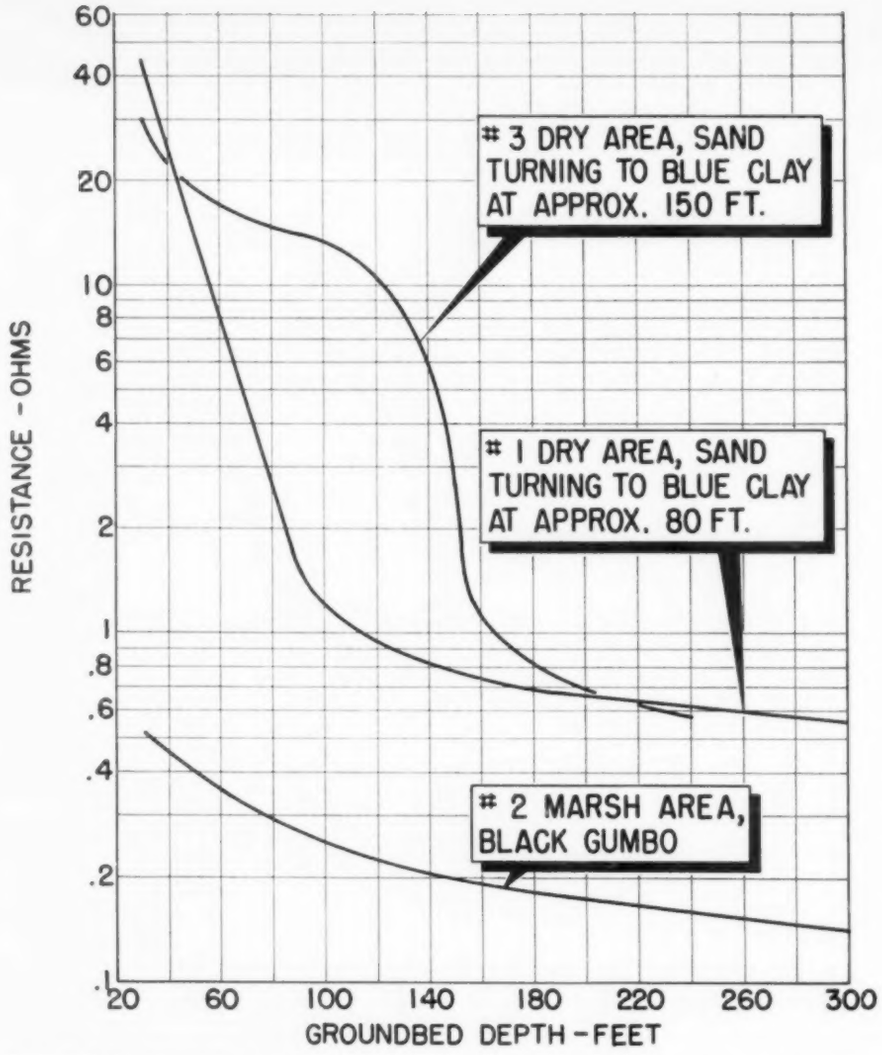


FIGURE 6—Circuit resistance log of deep groundbeds. Circuit resistance of completed rectifier installations determined from current output was lower than indicated by log. Resistance gradually increased and leveled off below the first value determined.

Why Deep Groundbeds?

1. Affords low resistant groundbeds in high resistant soil, making possible economic protection of bare pipe lines in high resistant soil.
2. Geometric location in relation to pipe line and low circuit resistance gives extensive coverage.
3. Interference problems with foreign structures are minor.
4. Engineering and corrosion surveying costs in locating low resistant soil are eliminated.
5. Expensive rights-of-way are reduced and can be eliminated, as deep groundbeds can be located on existing pipe line rights-of-way.
6. Resistance remains more constant with seasonal changes.
7. They have a cost advantage over normal surface types.

in a step-by-step method. In the first step, an 18-foot joint of casing with the lower end closed in orange peel fashion to prevent mud from entering the casing, is lowered into the hole. The lower 3½-feet of this joint is filled with coke breeze, and the first string of 3 graphite rods is placed in the center of the casing on top of the coke. 15 feet of #2 cable is attached to the bottom rod of this string, and the cable is bonded to the interior of the casing at the top. The void between the casing and string of rods is filled with coke breeze. As installed the rods protrude 6 inches above the coke-filled casing (Figure 3).

The second set of 3 graphite rods is attached to the first and a 15-foot joint of casing is lowered over the rods into place (Figure 4). Number 6 wire is fed through the second joint of casing and bonded to the first joint (Figure 5). The casing is then lowered and welded to the first joint of casing. The welded string of casing is lowered. Coke breeze is added to fill the annulus between the graphite rod and the casing. Weight is added by filling the casing with water. This procedure is repeated until all the rods are installed.

Extra cable attached to the last graphite rod is carried through the added 15-foot joint of casing with coke being added to all joints of casing to within 3 feet of the surface of the ground. The #6 wire is also carried through and bonded to each joint and to the 2/0 cable on the last joint of casing. The last 3 feet of casing is filled with gravel to filter any surface water entering the casing. Figure 1 shows the installation graphically.

Casing Preparation. Casing should be straight and cut to the lengths required. All ends should be smooth and square, so that the welded string of casing will be straight. The maximum length of casing that can be handled is 20 feet. Experience, however, has shown that faster progress can be obtained with 15-foot joints. All joints of casing, with the exception of the bottom joint which is 18 feet, are 15 feet long.

A terminal post should be welded on the interior close to the upper end of each joint of casing with a metal knob, old ¾-inch to 1-inch nut, welded on the exterior of each joint of casing

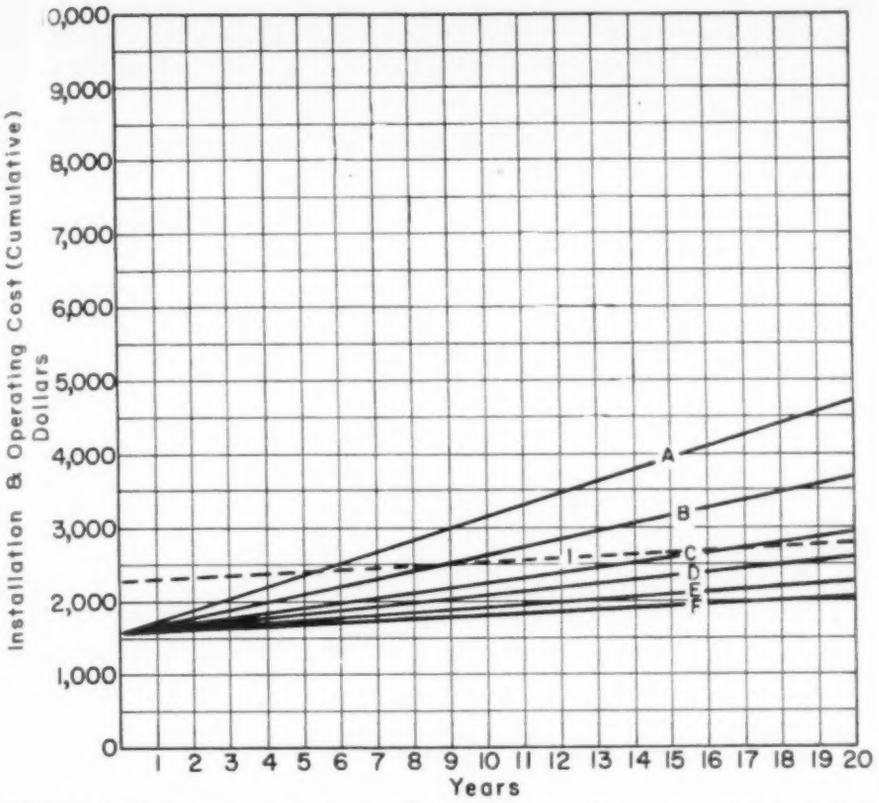


FIGURE 7—Cost comparison of normal and deep groundbeds. Cumulated operating cost for 10 ampere unit figured at various circuit resistances and power rates. Circuit resistance of units with deep groundbeds was 0.4 ohm.

LEGEND

A—3 Ohms, $.03 KWH
B—2 Ohms, $.03 KWH—3 Ohms, $.02 KWH
C—2 Ohms, $.02 KWH
D—1 Ohm, $.03 KWH—3 Ohms, $.01 KWH
E—1 Ohm, $.02 KWH—2 Ohms, $.01 KWH
F—1 Ohm, $.01 KWH—0.5 Ohm, $.01, $.02, $.03 KWH
1—Deep Groundbed, $.01, $.02, $.03 KWH

opposite the terminal. This knob helps prevent the string of casing from slipping through the bail. A 1-inch wide strip along the length of the casing and all welds should be wire brushed, cleaned, primed and coated with hot applied coal tar enamel. The coating will further insure continuity in the full string of casing during the final stages of consumption. All the above work, except coating of the joint welds, should be done prior to installation.

Cable Connections and Bonding. The connection between the #2 cable on two of the graphite rods, one at the bottom and the other at the top of the string of rods should be tight and sealed with resin cement. Special care should be taken in making the splice between the #2 cable on the bottom rod and the #6 wire and the splice between the #2 cable on the top rod and the 2/0 cable. All splices should be properly insulated.

Resistance Survey Locates Groundbeds. A soil resistance survey was made at each site selected, employing the four-terminal method. Separation of terminals was varied from 5 to 100 feet, giving an average soil resistance down to 100 feet. These data are presented in Table 2.

Survey at site #1 indicated a low resistance stratum below 75 feet. The drilling log of this well showed sand turning to blue clay at 80 feet. Site #2 was located in low resistance marsh soil, as indicated by the survey. Survey at site #3 indicated high resistance soil down to 100 feet. The log on this well showed sand and gravel turning to blue shale and clay at 150 feet.

A log of the circuit resistance of the casing and the pipe line at each site was taken as the casing was lowered, giving the resistance versus depth curves shown in Figure 6. These data indicate that there was no

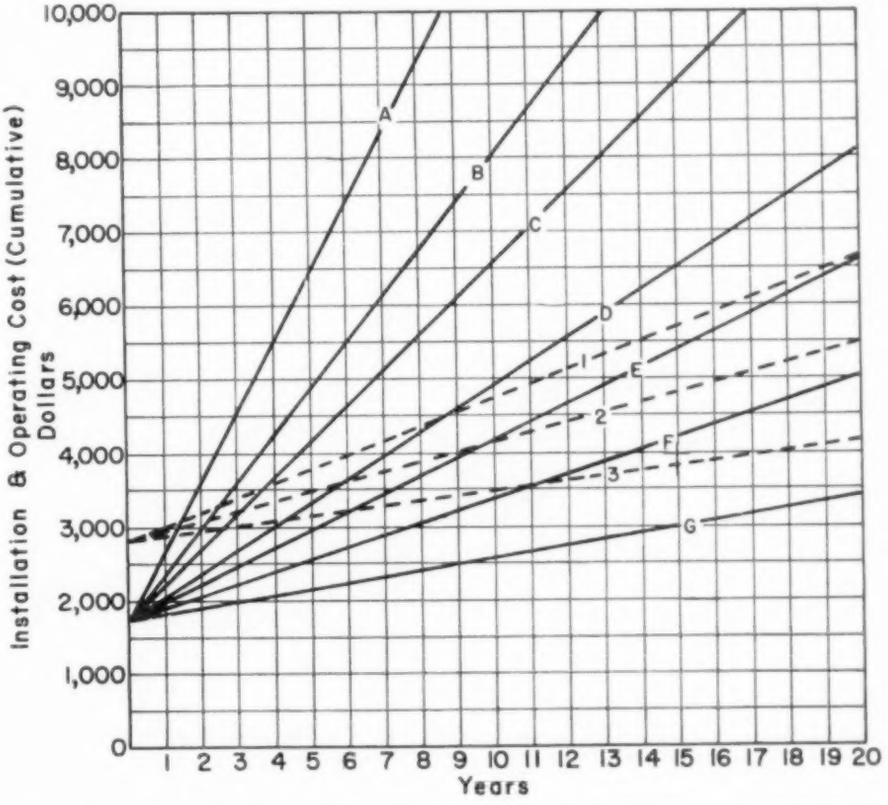


FIGURE 8—Cost comparison of normal and deep groundbeds. Cumulated operating cost for 30 ampere unit figured at various circuit resistance and power rates. Circuit resistance of units with deep groundbed was 0.4 ohms.

LEGEND

A—2 Ohms, $.03 KWH
B—2 Ohms, $.02 KWH
C—1 Ohm, $.03 KWH
D—1 Ohm, $.02 KWH—2 Ohms, $.01 KWH
E—0.5 Ohm, $.03 KWH
F—1 Ohm, $.01 KWH—0.5 Ohm, $.02 KWH
G—0.5 Ohm, $.01 KWH
1—Deep Groundbed, $.03 KWH
2—Deep Groundbed, $.02 KWH
3—Deep Groundbed, $.01 KWH

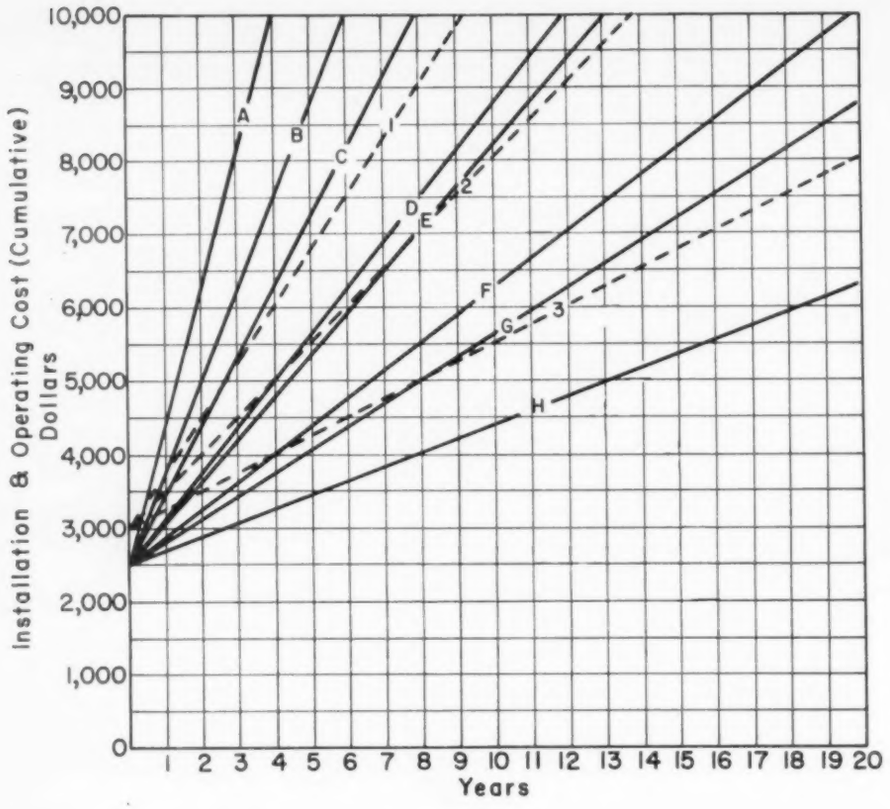


FIGURE 9—Cost comparison of normal and deep groundbeds. Cumulated operating cost for 60 ampere unit figured at various circuit resistance and power rates. Circuit resistance of units with deep groundbed was 0.4 ohm.

LEGEND

A—1 Ohm, $.03 KWH
B—1 Ohm, $.02 KWH
C—0.5 Ohm, $.03 KWH
D—0.5 Ohm, $.02 KWH—1 Ohm, $.01 KWH
E—0.3 Ohm, $.03 KWH
F—0.3 Ohm, $.02 KWH
G—0.5 Ohm, $.01 KWH
H—0.3 Ohm, $.01 KWH
1—Deep Groundbed, $.03 KWH
2—Deep Groundbed, $.02 KWH
3—Deep Groundbed, $.01 KWH

TABLE 1

Drilling			
Hole drilled 250 feet and set casing	@	$ 2/ft.	$ 500.00
Materials			
33-3″x60″ graphite rods	@	$10.50	$ 346.50
2-3″x60″ graphite rods with cable	@	12.85	25.70
100 ft.-2/0 PVC cable	@	.35	35.00
250 ft.- #6 PVC wire	@	.11	27.50
4,500 lbs.-coke breeze	@	.056	252.00
15 lbs.-resin cement	@	1.32	19.80
250 ft.-Grade #3, 8-⅝″ casing	@	.85	212.50
Lot-Misc. connections		5.00	5.00
		(Material Total	$924.00)
Supervision, labor and expense			745.00
Total Cost			$2,169.00

TABLE 2

Depth in Feet	Resistance in Ohm-Cm		
	Site #1	Site #2	Site #3
5	32,000	240	46,000
10	13,200	180	42,000
15	5,100	180	45,000
20	8,000	200	52,000
50	12,000	100	78,000
75	.....	160	105,000
100	4,000	200	70,000

need to go beyond 250 feet to get a low resistance groundbed in high resistance soil.

Actual Resistances Lower. Circuit resistance of each completed rectifier unit determined from the voltage and current output of each rectifier was lower than the resistance determined at the time the groundbeds were installed. Resistances have gradually increased as expected and have leveled off but are still below the first value determined. A protective spread of approximately one-third more than that obtained from units of like current output employing regular surface-type groundbeds was realized from rectifier units employing deep groundbeds. This is probably due to the position of the groundbed (anode) in relation to the pipe line (cathode) and the low circuit resistance of the deep groundbed unit.

Interference Reduced. Extensive tests by others have shown that interference problems with foreign structures are practically non-existent when deep groundbeds are employed, especially when the resistence of the groundbed is below 1 ohm. Tests at site #2 employing a normal surface-type groundbed show serious anodic interference with foreign lines with bonding drainage of up to 20 percent of unit output required to avoid damages. Tests with the deep groundbed at this site show only slight change from off to on with no bonding required.

Cost Comparison. The advantage of deep groundbeds over conventional graphite beds is further emphasized in the cost comparisons of normal versus deep groundbeds presented in Figures 7, 8 and 9. The installation cost in each example includes groundbed, connecting cable and mounted rectifier. An average installation cost was used for the conventional surface groundbed examples. These costs would be higher for high resistance soil and lower for low resistance soils. A minimum power charge is assumed for the deep groundbed in Figure 6, which is a scrap metal bed. Groundbeds in Figures 7 and 8 are graphite. Current requirements determine the life expectancy of scrap metal deep groundbeds. Scrap metal is more economical than graphite if a life of 15 or more years can be expected.

ACKNOWLEDGMENT
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About the Author

Robert L. Bullock, head of the Technical Services section, Engineering department, Interstate Oil Pipe Line Company, is responsible for corrosion, oil measurement and research groups. He has been associated with the Standard Oil Company of New Jersey group for 23 years. For the past 12 years he has served with oil pipe line companies. Bullock has planned and conducted a number of schools on corrosion, been in charge of research projects in the corrosion field, is a member of an API committee on external corrosion and is a past director of the National Association of Corrosion Engineers. He holds B.S. and M.S. degrees in electrical engineering from Texas A & M College.

By **Robert E. Schuhmann**
Supervising Engineer for
Compressor Stations
Trunkline Gas Co.
Houston

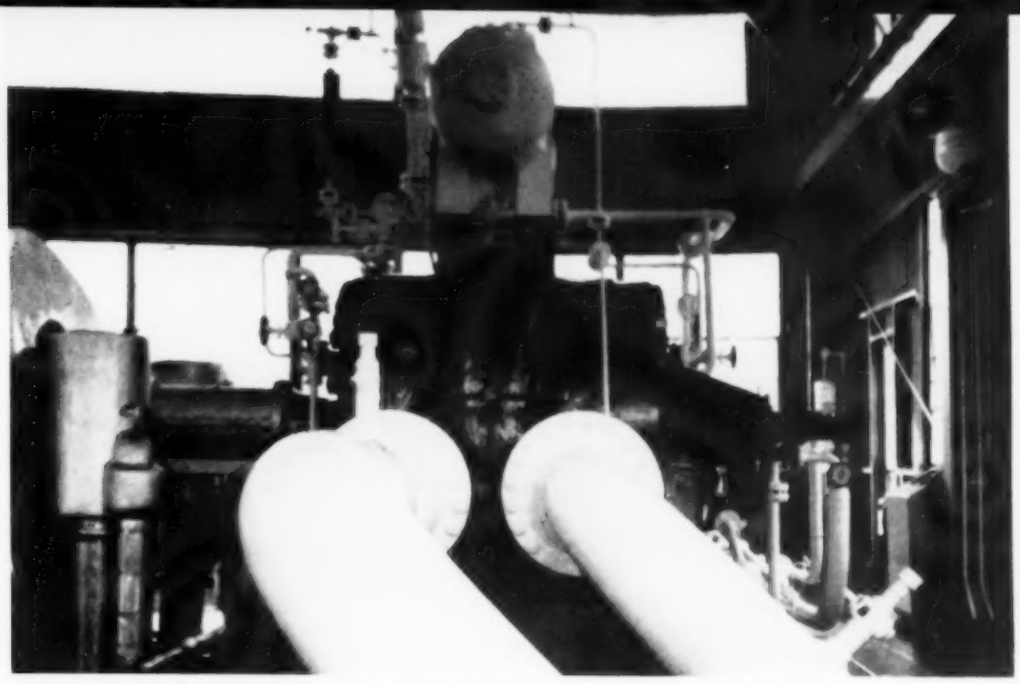


FIGURE 1—Series-parallel compressor viewed from the discharge side showing both discharge flanges. Coupling to turbine is at the left with seal oil pump on shaft extension at extreme right.

Series-Parallel Centrifugal Compressor Provides Pumping Flexibility

Four-impeller centrifugal compressor gives flexibility of reciprocating units over normal range of compression ratios

MAINTAINING OPERATING flexibility with a single line system dictates the design of compressor units on Trunkline's system. Technology and experience showed that a gas turbine prime mover should run for long periods without attention or maintenance. However, a single centrifugal compressor does not have the operating range to compare with a reciprocating compressor, and a series installation of centrifugal units could not stay in the design range in operation, would surge and would require wheel changes to follow changing line conditions.

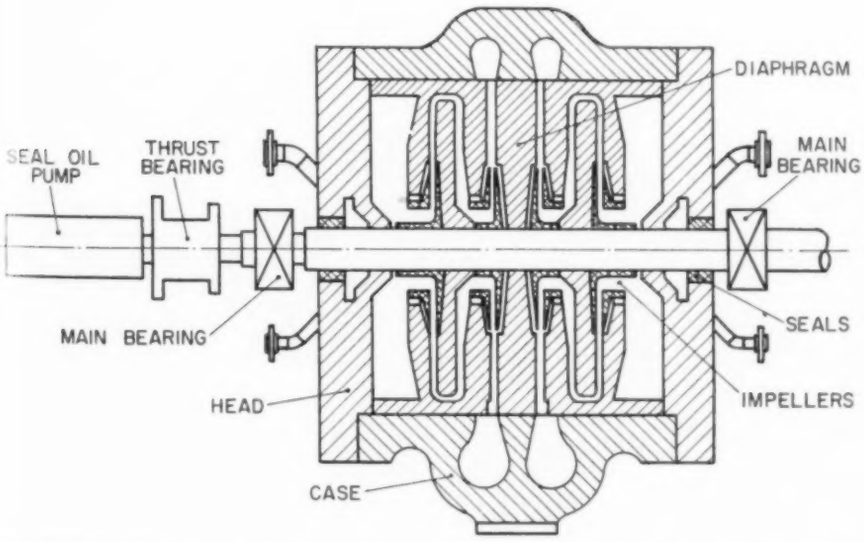


FIGURE 2—The compressor assembly consists of the barrel insert in the case, impeller and shaft assembly. After investigating dual impellers, tests proved the four-impeller design most satisfactory.

In order to evaluate turbines versus reciprocating engines for pipe line service, it was necessary to achieve the same flexibility in centrifugal gas compressors over the range of compression ratios; 1.2 to 1.75. A unique design which is basically two compressors in one case; each composed of two impellers (a total of four), and all on the same shaft was developed. Using this compressor an installation was possible which could be compared to previous reciprocating stations for performance, initial cost,

Components of Construction

WEIGHT OF PARTS

Case and heads	14,000 lbs.
Barrel and moving parts	26,000 lbs.
Total weight of compressor	40,000 lbs.
Weight of soleplate	15,000 lbs.
Emergency tank (seal oil supply)	4,000 lbs.
Total weight of unit	59,000 lbs.

DIMENSIONS

Soleplate—8 feet, 10 inches wide by 9 feet, 5½ inches parallel to shaft.

Face-to-face distance on flanges—9 feet, 6 inches.

Flanges 16-inch ASA 600 octagonal groove ring joint.

Unit set on 2 feet, 3-inch pedestals on the soleplate and shimmed.

Emergency seal oil tanks mounted on top of compressor, 8 feet long, 2 feet O.D.

Overall height of unit including tank, 11 feet, 3 inches.

Flanges spaced 32 inches O.C. at 2 feet, 9-inch center line above top of soleplate.

fuel, labor, downtime and total cost of ownership.

Design Considerations. Achieving the necessary compression ratio using only two wheels of large diameter and high specific speed was examined, tested and eliminated before settling on four wheels of slightly smaller diameter. This final design permitted:

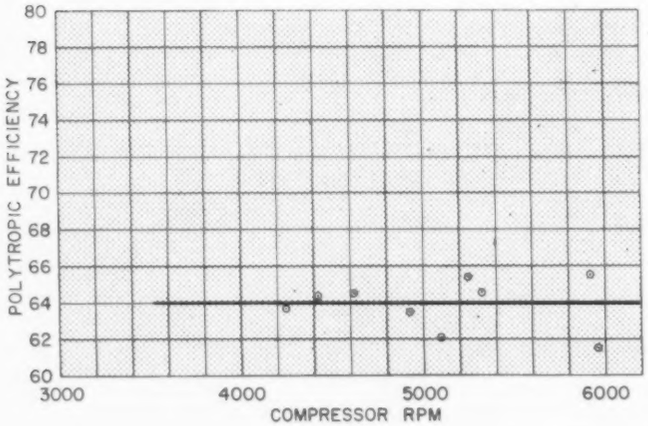
- A low specific speed.
- Small pressure rise per wheel; 82 psi average at station design point of 1.57 compressor ratio.
- Low Mach number of impeller rim; 0.44 at maximum speed and compression ratio.
- A nearly linear relation for rate of increase of impeller flow area with radius of impeller; cited by some designers as necessarily constant.
- A reasonably large clearance (0.25 inches on the radius) between impeller and diffuser; though set by some designers at as much as one-tenth of the diameter. Axial clearance on high pressure side of impellers is ⅜ inch, on low pressure side ⅛ inch.
- A vaneless diffuser.

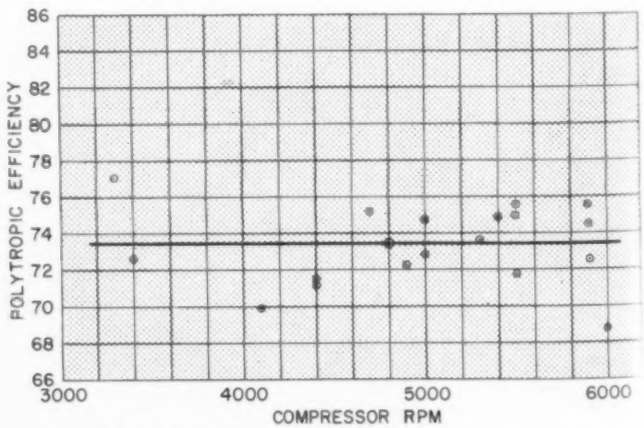
The "barrel and parts" assembly is comprised of the barrel insert in the case, impeller and shaft assembly as shown in Figure 2.

Efficiency Increased. A low polytropic efficiency (60-65 percent) was experienced with the dual impeller design first investigated, whereas, all other things remaining constant, the polytropic efficiency of the four impeller unit increased to 74 percent, as illustrated in Figure 3. Present polytropic efficiency of near 80 percent is attributed to a revision of the sealing system after installation.

Using the dual impellers also revealed a higher noise level near the compressor, since the impeller to diffuser clearance was small; creating a siren effect. The increase in polytropic efficiency with the sealing system revision was accomplished by the elimination of internal gas leakage from the seal on the high pressure side to the seal on the low pressure side.

Safety from Surge Provided. External piping is simplified by having





At left initial installation using two-wheel impeller at Edna station. Above, data from June to September, 1958, at Kount Station.

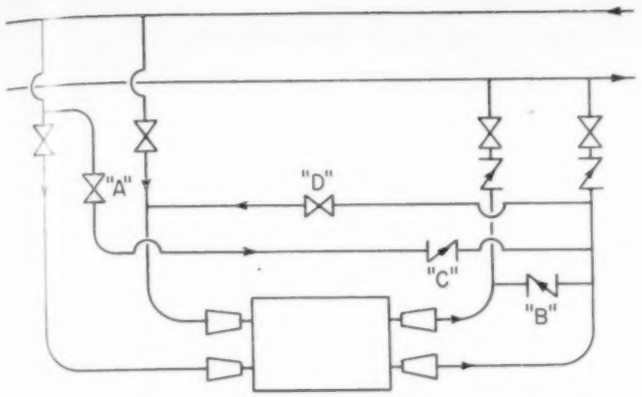


FIGURE 4—External piping is simplified by having both suction nozzles on the same side of the unit with the two discharge nozzles on the opposite side. Suction and discharge loading valves are 18-inch plug valves actuated by piston-driven gear and rack operators. Check valves protect compressor from surge flow in reverse direction. Seals and diaphragm between two stages are protected by pressuring valve "A."

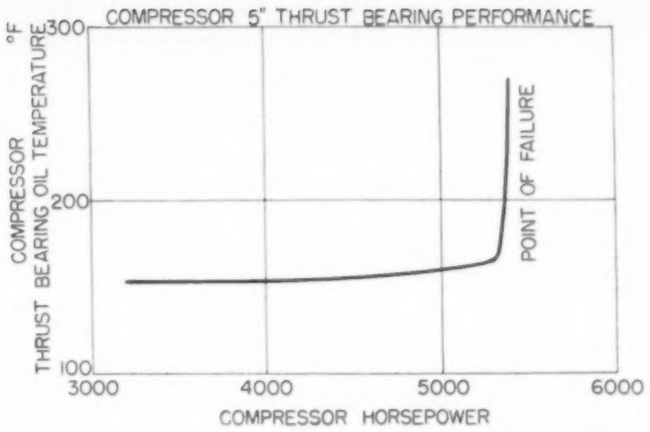


FIGURE 5—A 5-inch thrust bearing was tested, but failed from overload. Seven-inch and 9-inch bearings were also tested; the 7-inch was selected and has run satisfactorily with only normal wear for 23,000 operating hours.

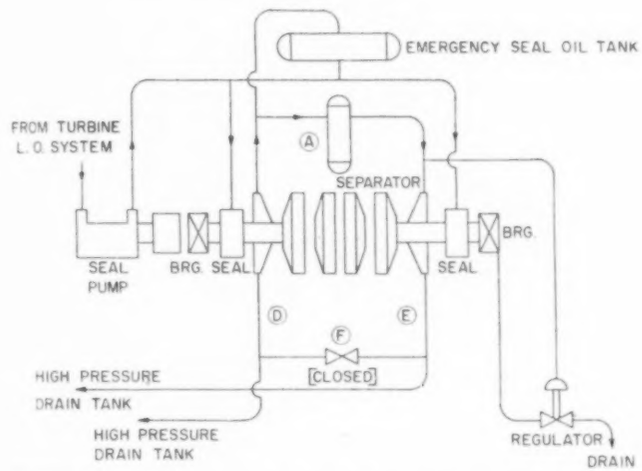
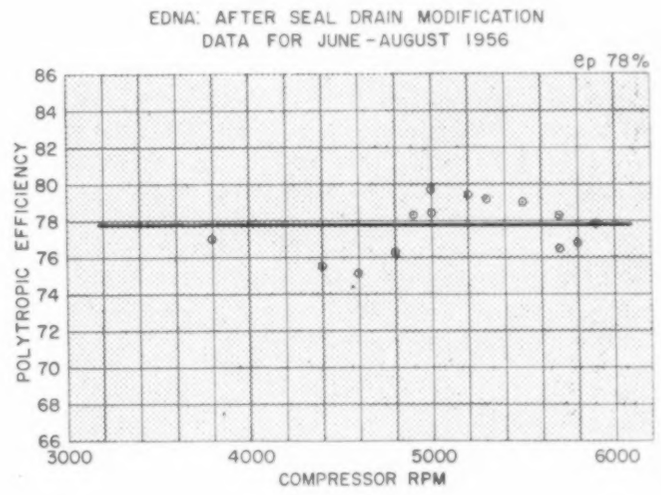


FIGURE 6—Even though the shaft seals on opposite ends of the case are retaining a gas stream at two different pressures, only a single seal system is used. Gas is drawn from the high pressure side to the low pressure side so that both seals see a fluid pressure between the second and first stage suction.



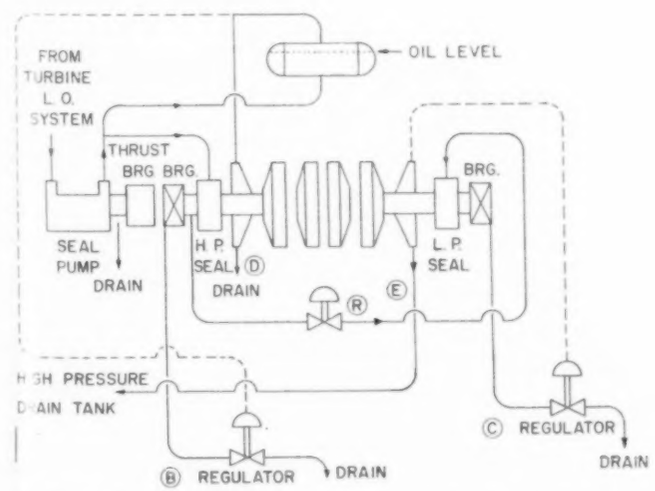


FIGURE 8—A further modification controls oil flow from high to low pressure side with regulator "R" sensing pressure differences across the high pressure seal. Regulators "B" and "C" provide back pressure on seals and main bearing.

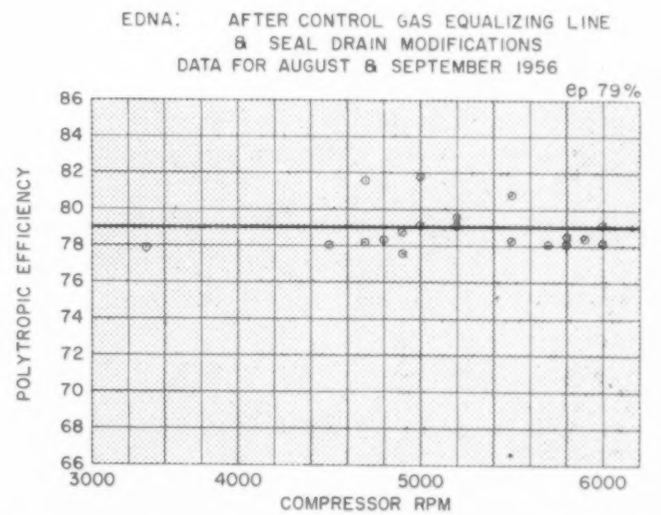


FIGURE 7—Installing centrifugal separator "A" and valve "F" increased the polytropic efficiency of the unit at Edna station. In addition to increasing the efficiency, this modification recovered from 20 to 80 percent of the oil lost from the seal system.

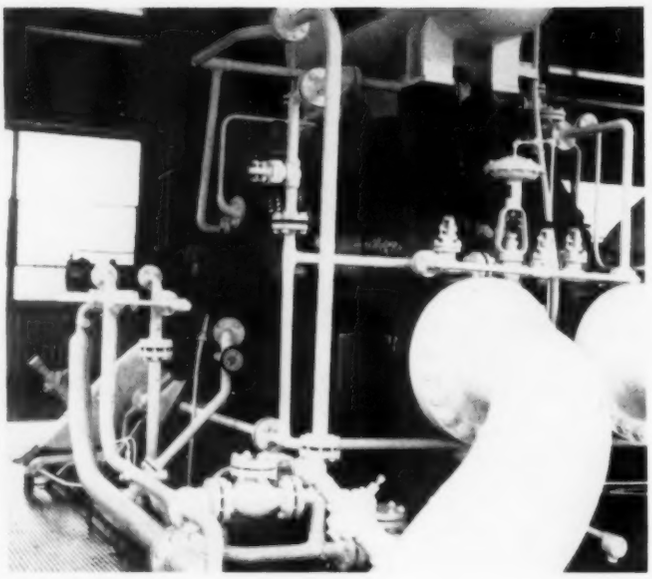


FIGURE 9—Outboard end of compressor viewed from suction side. Both gas suction flanges are at right with seal oil pump on unit shaft at left. Regulator "R" of Figure 8 is at right above suction flanges.

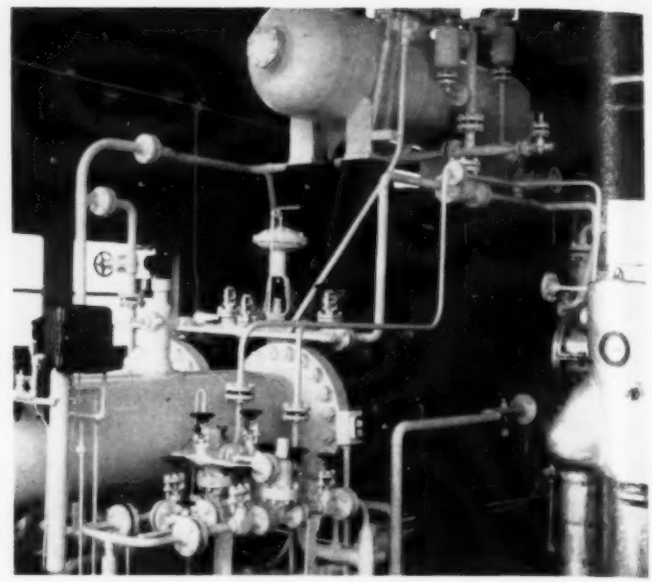


FIGURE 10—Inboard end of compressor viewed from suction side with prime mover to the right. Back pressure regulators at lower left are seal oil control regulators "B" and "C" of Figure 8.

both suction nozzles on the same side of the unit with the two discharge nozzles on the opposite side. Suction and discharge compressor loading valves are 18-inch plug valves actuated by piston driven gear and rack operators, facilitating remote power operation of the unit from the control room. Two 18-inch check valves protect the compressor from destructive surge flow of gas in the reverse direction. External piping is illustrated in Figure 4.

Compressor seals and the diaphragm between the two stages are protected by the pressuring valve "A." Prior to opening the 18-inch valves, this valve pressurizes the compressor case admitting gas simultaneously to the second stage suction and first stage discharge, thus minimizing pressure difference across the diaphragm.

Internal flow is such that the gas path is from the outer head toward the middle of the case, with the impellers of the two stages placed back to back, keeping the lowest pressures on the shaft seals, as well as minimizing the difference across the diaphragm separating the two stages. In addition to reducing the strength requirements of the diaphragm, less leakage is involved through the labyrinth; increasing polytropic efficiency.

Internal Construction. Impellers are 25 inches O.D. giving a tip speed of 643 feet per second at 5,900 rpm. Diffuser is vaneless type, 25½ inches I.D. and 38 inches O.D. Shaft is stepped in diameter to avoid critical frequencies. Standard labyrinth is found between all impeller stages. Diaphragm is a nearly flat cast steel disc, 3⅜ inches thick at the labyrinth near the shaft, widening and cored near the outer diameter.

Main bearings are babbitted sleeve 2¼ inches long by 4¾ inches in diameter. The Kingsbury thrust bearing is set outboard of the main bearing on the high pressure side of the compressor case. A 5-inch bearing was tested, but failed from over-load as shown in Figure 5. Seven-inch and 9-inch bearings were also tested; the

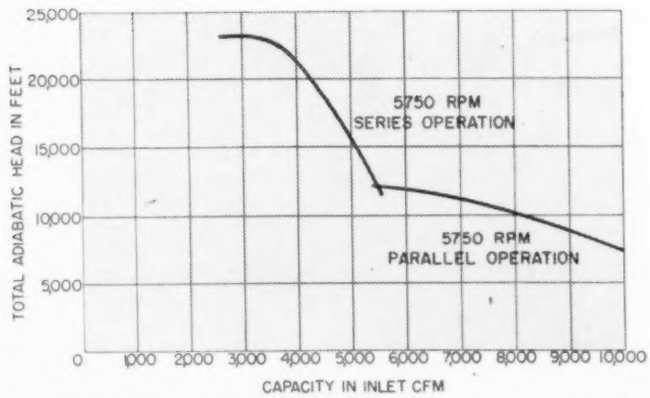


FIGURE 11—Head-capacity curve allows comparison with other units. This plot is derived from data collected at Trunkline's Edna station. Flow obtained with a 24-inch meter. Pressure and temperature data were obtained with dead weight gages and liquid-in-glass thermometers. Gas sp. gr. 0.585, suction temperature 70° F.

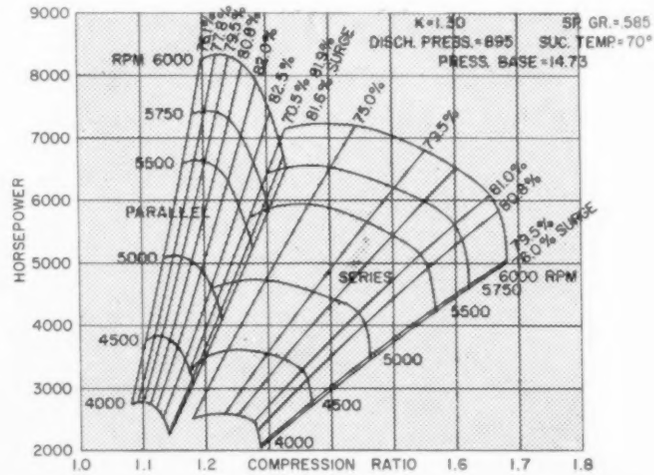


FIGURE 12—Compressor performance curves allow comparison of a given unit under varying conditions. Greatly enlarged plane of operation of series-parallel unit over a single stage compressor is demonstrated by this chart. Data collected at Kountze station. Design volume 4,500 CFM (Series).

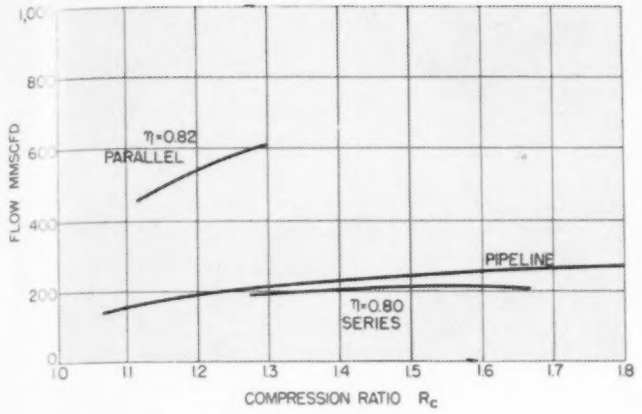


FIGURE 13—System flow plotted against compression ratio presents the inherent match of a centrifugal compressor to a pipe line. In this illustration constant compressor efficiency conforms very closely to a pipe line curve. Compressor curves at constant compressor efficiency. Discharge pressure 895 psia.

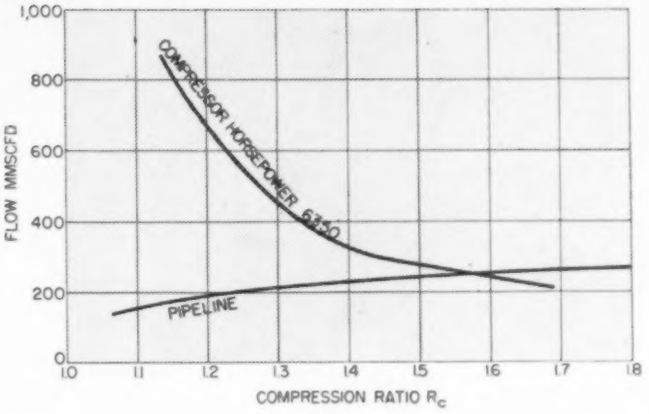


FIGURE 14—In gas transmission system design, families of curves are usually constructed. Design operating point is determined by intersection of pipe line and compressor curves. With the series-parallel unit the range is extended to compression ratios below 1.3.

7-inch was chosen and has run satisfactorily with only normal wear for 23,000 operating hours. Since the single case houses all impellers, the unit requires only two shaft seals. This is probably optimum for this size and speed unit, since an overhung impeller would have presented other difficulties. With this design the main seal oil pump can be directly shaft driven.

Seal Design. Even though the shaft seals on opposite ends of the case are retaining a gas stream at two different pressures, only a single seal system is used. As shown in Figures 6 and 8 this is accomplished in two different ways. One is to draw gas from the high pressure side to the low pressure side so that both seals see a fluid pressure somewhere intermediate between second and first stage suction. With the compressor operating in parallel, there is no bleed of gas. In the other method, the seals operate at two pressure levels. Leakage is prevented by controlling the oil supplying the seals.

The simplified schematic in Figure 6 illustrates the first seal system tested without the equalizing line separator at "A" and the valve at "F." Since both seals have a common oil supply while the retained gas pressures varied, these equalizing lines are necessary to equalize the downstream pressure on the two seals. Without this equalizing line, two separate seal systems would be required.

Oil Loss a Problem. Along with the loss of gas from high stage to low stage, the inherent construction of the machine with this gas flow in the equalizing line was causing a high carry-over of oil from one seal drain chamber to the other, and hence a large loss into the main pipe line.

From 20 to 80 percent of oil lost from the system was recovered after installing the centrifugal separator "A" and valve "F." Pressure regulators in both oil supply and gas lines would give the same results. Figure 7 shows results of this revision.

A further modification served to control seal oil flow from one seal to the other. This system (Figure 8) controls oil flow from high to low pressure side with regulator "R" sensing pressure difference across the high pressure seal. The regulator is a fail-safe instrument providing oil to the low pressure seal and main bearing. Regulators "B" and "C" provide back pressure on the seals and main bearings; the oil being the same for all services. The combined oil system for the compressor and turbine prime mover consumed approximately one gallon of oil in 50,000 BHP-Hrs.

Comparison With Other Units. In comparing the series-parallel centrifugal compressor with other units, the Head-Capacity curve shown in Figure 11 is of interest. This plot was derived from test data obtained at Trunkline's Station No. 23, Edna, Texas. All compressor unit gas flow data was obtained with a 24-inch meter in the discharge gas piping in the station yard. Pressure and temperature data were obtained with dead weight gages and liquid-in-glass

Operating Specifications

Normal discharge pressure	900-1,000 psig
Capacity in series (at best efficiency point)	208 MMscfd
Capacity in parallel (at best efficiency)	600 MMscfd
Normal compression ratio range in series (at best efficiency)	1.28 to 1.67
Normal compression ratio range in parallel (at best efficiency)	1.12 to 1.3
Maximum compression ratio range (with inlet guide vanes)	1.08 to 1.82
Maximum speed	5,900 rpm

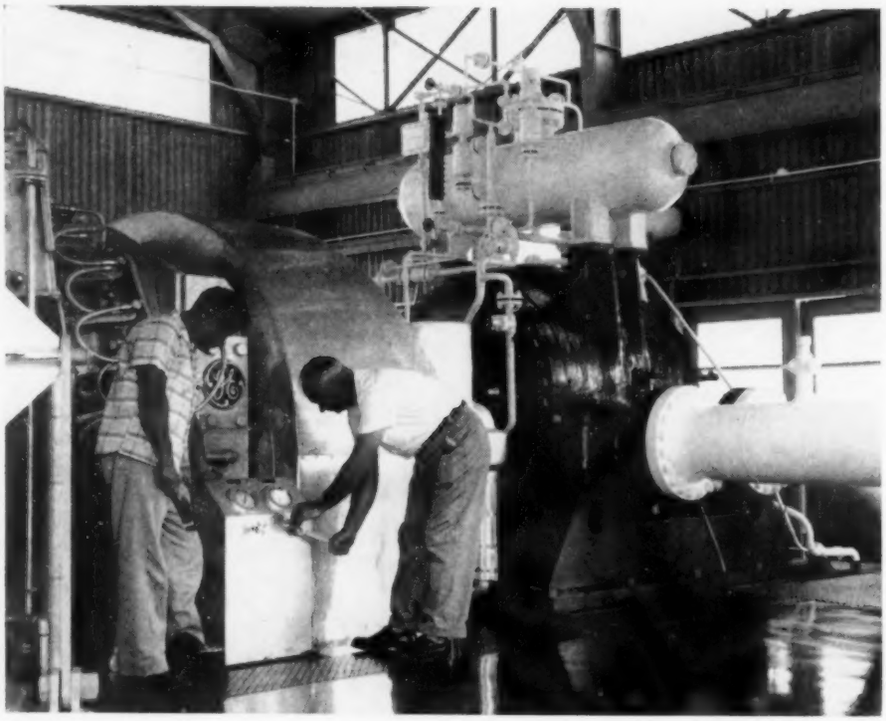


FIGURE 15—Compressor building operating floor showing compressor at right center with portion of gas turbine on left. Seal oil tank is mounted on top of compressor, along with level controls and supply piping to unit. Compressor gas discharge flanges are at right.

thermometers. Using inlet guide vanes will shift the Head-Capacity curve toward higher head and lower capacity. This is done at Station 8, Premont, Texas, where a higher station discharge pressure at lower flow is required. All other units are identical.

Advantages of Series-Parallel Compressor. The adiabatic efficiency by heat balance is the quantity most conveniently used for performance comparison of a given unit under varying conditions. A very convenient plot of this type is the BHP vs. Compression Ratio curve shown in Figure 12. Operating comparison with reciprocating compressors can also be made with this chart.

One advantage of the series-parallel machine demonstrated by this plot is the greatly enlarged plane of operation over a single stage machine. The bhp/MMscfd compressed curve for this machine would be a family of curves for varying efficiencies similar in appearance to Figure 12. To achieve this wide band of operations and be capable of operating alongside reciprocating compressors, the impeller design must of necessity be a compromise. Yet, the efficiency at low ratios is higher than with many reciprocating compressors.

System flow plotted against compression ratio presents the inherent match of a centrifugal compressor to a pipe line; flow being plotted with the Panhandle equation. Figure 13 shows a plot where constant compressor efficiency conforms very closely to a pipe line curve. As additional pipe line loops are added, the compressor performance is still within the bounds of pipe line flow; though at a different efficiency. For simplicity only two efficiency curves are plotted since the major portion of the field is covered in Figure 12. For convenience, the curves in Figure 13 are plotted for a constant station discharge pressure. If the pressure changes, the curves shift relative to the ordinate.

During the design of a gas transmission system, families of curves similar to Figure 14 are usually constructed. Design operating point is determined by the intersection of the pipe line and compressor curves. Regardless of the type of compression used, these curves have the same general characteristics. With the series-paralleled unit, however, as opposed to single wheel centrifugals, the compressor operating range is extended into the lower compression ratios; below 1.3. As seen in Figures 12 and 14, this design for centrifugal compressors enables the prime mover to be fully loaded to very low operating compression ratios.

Cost Similar to Reciprocating Units. On the basis of the first year's satisfactory experience with the first unit, two additional units were installed in 1955. Since the first modification of the seal oil and control and equalizing gas line systems, the units have operated since the summer of 1956 with no down-time attributed to the gas compressors. The only interruption has been for scheduled maintenance and inspection of the turbine prime movers or other station facilities. Total operating hours since 1956 are:

- Station 8 at Premont—14,600 hours
- Station 23 at Edna—15,000 hours
- Station 40 at Kountze—14,200 hours

Installed cost of a series-paralled centrifugal station has proved to be the same as any other type compressor and prime mover combination. With station operating costs (fuel, labor etc.) the same, the cost of ownership for this type unit will be the same as for reciprocating equipment.

ACKNOWLEDGMENT

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About the Author

Robert E. Schuhmann, supervising engineer for compressor stations for Trunkline Gas Company, Houston, is a graduate of The University of Texas with a degree in mechanical engineering. He remained at Texas for two years as an instructor in heat power, thermodynamics and machine design. Pipelining experience includes seven years in design and construction of compressor stations as well as pipe line construction. He is a member of ASME, National Society of Professional Engineers and is president of the Pipe Liners Club of Houston.

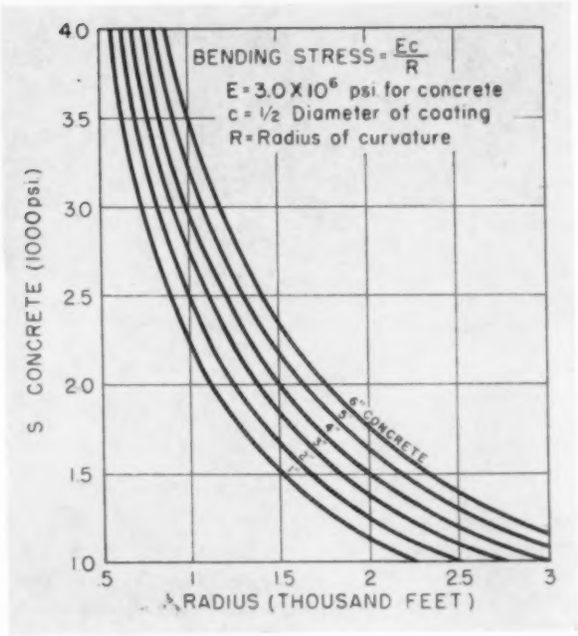


FIGURE 1—Concrete flows plastically under stress, but has practically no strength in tension. Curves were plotted for the minimum allowable radius to which 16-inch concrete coated pipe could be bent. Previous experience has indicated a maximum stress of 2,500 psi for concrete coated pipe.

Pipe Stress in Offshore Construction

Using a theoretical analysis of stresses encountered during construction, specifications can be written which will prevent damage to the pipe

By Noah Roads, Engineer
Tennessee Gas Transmission Company, Houston

STRESSES IN offshore pipe line construction are more critical than in land construction because of the large expense in time and money of repairing any failures. Also, conditions causing excessive stresses, if present, would probably be sustained for longer periods of time.

Three types of construction damage must be guarded against:

- Buckling or weakening carrier pipe.
- Concrete coating spalling due to excessive bending.
- Excessive cracking of concrete coating.

In all the examples checked, the third condition would occur first, so if the laying procedures satisfactorily prevent excessive cracking of concrete coating, the other types of construction damage will be eliminated.

Pipe must always be installed in such a way that it has its rated strength when in place. It is important to the stability of the pipe line that weight coating remains intact so that the pipe will maintain designed alignment and depth.

In the general concept in bending, concrete will crack when in tension. Inspectors have relied on visual inspection to determine whether cracking is excessive.

In September, 1955, Tennessee Gas Transmission Co. started a program of testing pipe line coatings and weight coatings. One phase of this project was the observation of 52 prepared specimens of 6-inch pipe about 7 feet long, using several different types of pipe line coating and weight coating. These specimens were immersed in Galveston Bay near the Houston Ship Channel in January, 1956. Thirty-four of the specimens had weight coatings.

Eliminating Stresses During Construction. Proposals for construction can be divided into three general types: the negative buoyancy—towing pipe string along bottom; point support; and launching shoe.

Negative Buoyancy—Bottom Tow. In the negative buoyancy method the pipe is assembled on land with buoys attached for flotation as it enters the water. As the section moves away from the beach, enough buoys are released to give the pipe a small negative buoyancy. The pipe is then towed, resting lightly on the bottom, to the offshore right-of-way. Working from a tie-in barge, the ends of the pipe are lifted, aligned and welded. After the weld is made the pipe is lowered again to the bottom.

Critical stresses are developed in raising the pipe to surface, aligning the ends and lowering back to the bottom. In the proposal studied, the welds were to be made approximately 5 feet below water level in a water tight welding chamber which had been pumped dry.

Other suggestions using the nega-

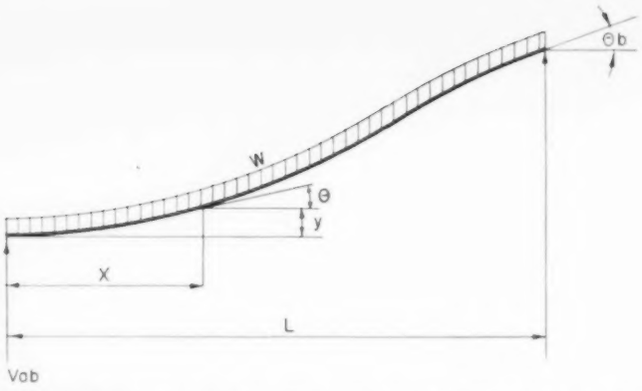


FIGURE 2—Negative bouyancy method of launching the pipe conforms closely to a beam with uniform loading, fixed on the upper end and infinite in length, the lower end resting on a level surface.

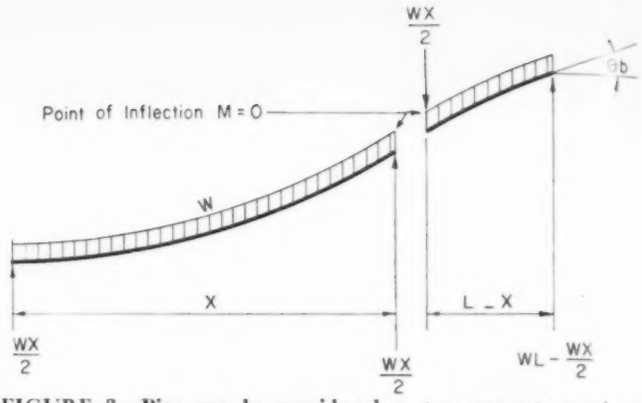


FIGURE 3—Pipe can be considered as two separate portions; the sag as a simply supported beam, and the overbend as a cantilever with a load on the end and a uniform load. This force diagram shows the point of inflection.

tive buoyancy method were based on launching the pipe from the rear of the barge as it is assembled.

Point Support Method. In the point support method the pipe is supported by derricks, auxiliary barges or large, widely-spaced buoys so that the elevation of supports can be regulated to predetermined positions.

Launching Shoe Method. The launching shoe is a frame (or ladder) of two line pipe braced together with rollers fixed to guide the pipe to its resting place on the bottom. Although similar to the negative buoyancy method, there is increased stiffness. Buoyancy can be regulated by filling or emptying the two main pipes in the shoe. If the buoyancy of the shoe is the same as the weight of the pipe, the shoe will become approximately straight and the lower end of the pipe will act as if it were freely supported.

Analysis of Construction Methods. At first a purely mathematical approach was taken, after which laboratory tests were made to detect any oversight in the theory. Bending tests were made on several shapes including long rectangular and round rods, 1-inch galvanized pipe and 4½-inch line pipe.

In the tests the bottom was laid on a level surface, with the upper portion over a knife edge. The test piece was made level at the upper support by adding weight on the overhang. Elevation of the upper support was varied to study the stresses incurred at different heights of lift. To study the effects of different types of soil on the ocean floor, the 1-inch pipe was tested with the lower portion on a hard surface and on soft sand. Strain gage readings were made on the 1-inch and 4½-inch O.D. pipe to determine stress distribution along the pipe.

Field checks were made on the actual conditions of laying. In the field checks, elevations were taken on the pipe at various points and plotted on cross-section paper. The radii of curvature were calculated over short sections of the pipe (as circular arcs). Laying conditions were analyzed as closely as possible; expected radii of curvature were calculated from this analysis and compared to those found by field checks.

Theoretical Calculations. Bending moment was considered to be the only force of sufficient magnitude to possibly injure the pipe or coating.

The following equations show the relationship between moment, radius of curvature and stress for elastic members in bending:

$$M = \frac{SI}{C} = \frac{EI}{R} \qquad (1)$$

Solving for S

$$S = \frac{EC}{R} \qquad (2)$$

Although concrete flows plastically under stress and has practically no strength in tension, Equations 1 and 2 give a method of comparing the stress on the concrete coating. Stress vs. radius of curvature was plotted for various diameter pipes with coatings of concrete from 1 inch to 6 inches using E for concrete $= 3 \times 10^6$. Figure 1 shows curves plotted for 16-inch O.D. pipe.

In previous experience with concrete coated pipe, an indicated stress of 2,500 psi on the concrete appeared to be about the maximum for safety. The radii of curvature were read from the prepared graphs as follows:

26″ — 1,700′
20″ — 1,400′
16″ — 1,000′
12″ — 750′

These radii of curvature produce a stress in steel of about 20,000 psi, which was considered a safe working stress for steel.

In this way the minimum radius of curvature for various sizes of pipe was determined. Having established the relationship between moment, bending stress and radius of curvature, analysis of the forces on the

Explanation of Symbols

M	Moment—in. lbs.
M_a	Moment at point pipe touches bottom—O
M_b	Moment at point of last support—in. lbs.
M_c	Moment at center of sag Portions of pipe—in. lbs.
M_{fa}	Fixed end moment at A if both ends are fixed
M_{fb}	Fixed end moment at B if both ends are fixed
L	Unsupported length of pipe—in.
x	Horizontal distance from origin—in.
y	Vertical distance from origin—in.
y_b	Height of support above bottom—in.
Θ	Angular deflection from horizontal—radians
Θ_b	Angle of pipe at last support—radians
E	Modulus of elasticity—psi = 30 x 10^6 for Steel
I	Moment of inertia of pipe—in.
R	Radius of curvature—in.
S	Maximum bending stress in section—psi.
C	Constant of integration
w	Net load on pipe—lb/in.
Z	Section modulus—in.
c	Distance from neutral axis of section to outer fibers—in.
V_{ab}	Shear at A in direction at B —lbs.

pipe will determine the moment present under any loading condition.

Moment Equation Derived. In a stress analysis the negative buoyancy method conforms closely to a beam with uniform loading fixed on the upper end and infinite in length, the lower end resting on a level surface. The Gulf floor has a very gentle slope in the areas where these lines were to be laid.

At the point of rest the moment and slope become zero. The general moment equation of a uniformly loaded beam is:

$$M = M_a + V_{ab}x - \frac{wx^2}{2} \qquad (3)$$

But $M_a = 0$

Therefore $M = V_{ab}x - \frac{wx^2}{2}$

Integrating

$$EI\Theta = \frac{V_{ab}x^2}{2} - \frac{wx^3}{6} + C_1 \qquad (4)$$

at $x = 0$, $\Theta = 0$, Therefore $C_1 = 0$

at $x = L$, $\Theta = \Theta_b$, Therefore

$$EI\Theta_b = \frac{V_{ab}L^2}{2} - \frac{wL^3}{6}$$

Solving for V_{ab}

$$V_{ab} = \frac{2EI\Theta_b}{L^2} + \frac{wL}{3} \qquad (5)$$

V_{ab} is also the reaction at the bottom

Combining 3 and 5

$$M = \frac{2EI\Theta_b x}{L^2} + \frac{wLx}{3} - \frac{wx^2}{2} \qquad (6)$$

Solving for $M = M_b$ at $x = L$

$$M_b = \frac{2EI\Theta_b}{L} + \frac{wL^2}{3} - \frac{wL^2}{2} = \frac{2EI\Theta_b}{L} - \frac{wL^2}{6} \qquad (7)$$

Combining 4 and 5

$$EI\Theta = \frac{EI\Theta_b x^2}{L^2} + \frac{wLx^2}{6} - \frac{wx^3}{6} \qquad (8)$$

Integrating (8)

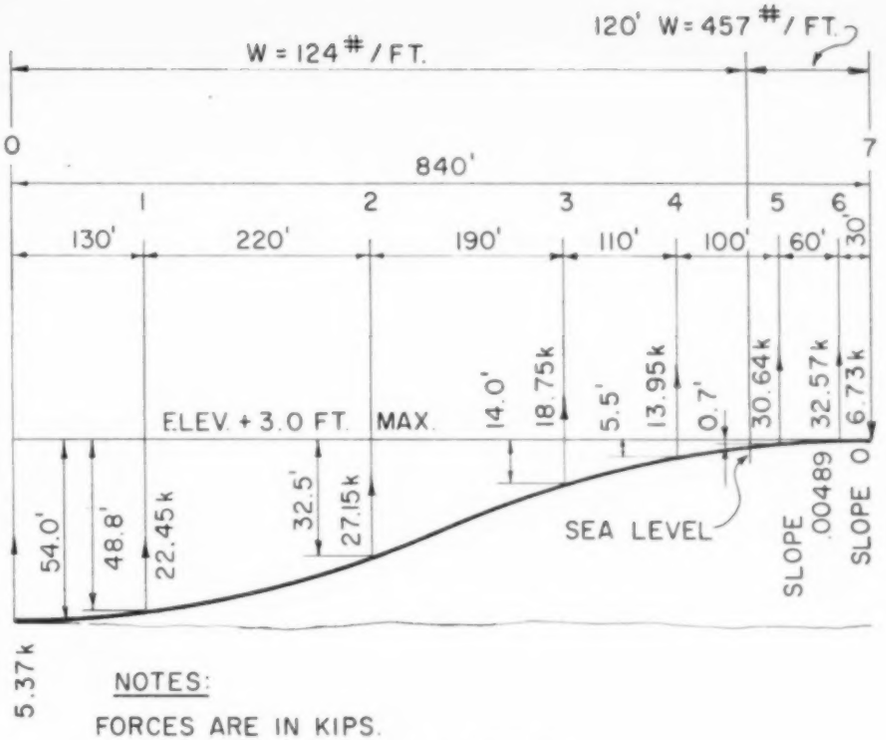
$$EIy = \frac{EI\Theta_b x^3}{3L^2} + \frac{wLx^3}{18} - \frac{wx^4}{24} + C_2 \qquad (9)$$

at $x = 0$, $y = 0$, Therefore $C_2 = 0$

Solve (9) at $x = vL$ $y = y_b$

$$EIy_b = \frac{EI\Theta_b L}{3} + \frac{wL^4}{18} - \frac{wL^4}{24} = \frac{EI\Theta_b L}{3} + \frac{wL^4}{72} \qquad (10)$$

$$\left(\text{or } y_b = \frac{\Theta_b L}{3} + \frac{wL^4}{72EI}\right)$$



NOTES:

FORCES ARE IN KIPS.

VERT. DEFLECTIONS ARE APPROX. (PLUS OR MINUS 0.5 FT.)

FIGURE 4—Proposal for laying 26-inch pipe in 50 feet of salt water. Minimum radius of 2,040 feet was desired. Supports were buoys with ballast chambers. Deflection was determined by integrating the diagram graphically.

Stress and Radius of Curvature Calculated. If the launching angle, loading on pipe and depth of water are known, the unsupported length can be calculated from Equation 10. This unsupported length can be substituted in Equation 7 to determine moment at the top. From Equation 1 the stress and radius of curvature can be calculated for comparison with safe values.

Solve (10) for w

$$\frac{wL}{72EI} = y_b - \frac{\Theta_b L}{3} \text{ or } \left(w = \frac{72EIy_b}{L^4} - \frac{24EI\Theta_b}{L^3}\right) \qquad (11)$$

The value of radius of curvature is given by

$$M = \frac{EI}{R}$$

Combining (1) and (6) and (11)

M_b can be shown to be less than zero

$$M_b = \frac{-EI}{R} = \frac{2EI\Theta_b}{L} - \frac{L^2}{6}\left(\frac{72EIy_b}{L^4} - \frac{24EI\Theta_b}{L^3}\right)$$

$$\frac{-EI}{R} = \frac{2EI\Theta_b}{L} - \frac{12EIy_b}{L} + \frac{4EI\Theta_b}{L} \qquad (12)$$

Multiply (12) by $\frac{RL^2}{EI}$

$$-L = 6R\Theta_b L - 12Ry_b$$

Regroup terms and complete the squares

$$L^2 + 6R\Theta_b L + 9R^2\Theta_b^2 = 12Ry_b + 9R^2\Theta_b^2$$

taking square root of both sides

$$L + 3R\Theta_b = (12Ry_b + 9R^2\Theta_b^2)^{1/2}$$

$$L = (12Ry_b + 9R^2\Theta_b^2)^{1/2} - 3R\Theta_b \qquad (13)$$

If radius of curvature, launching angle and depth of water are specified. Equation 13 can be used to find the unsupported length. Then Equation 11 will give the loading to make the pipe conform to this shape.

Maximum Moment Determined. So far, only the moment at the upper end has been considered, this may not be the maximum moment.

The point of inflection can be determined by setting $M = 0$

$$M = \frac{2EI\Theta_b x}{L^2} + \frac{wLx}{3} - \frac{wx}{2} = \frac{2EI\Theta_b}{L^2} + \frac{wL}{3} - \frac{wx}{2} - 0 \qquad (6)$$

Solving for x

$$\frac{wx}{2} = \frac{2EI\Theta_b}{L^2} + \frac{wL}{3}$$

$$x = \frac{4EI\Theta_b}{wL^2} + \frac{2L}{3} \qquad (14)$$

$$\text{Then } L - x = \frac{L}{3} - \frac{4EI\Theta_b}{L^2} = \frac{-2}{wL}\left(\frac{3EI\Theta_b}{L} - \frac{wL}{6}\right) \qquad (15)$$

$$L - x = \frac{-2M_b}{wL}$$

The pipe can be considered as two separate portions: the sag as a simply supported beam, and the overbend as a cantilever with a load on the end and a uniform load (Figure 3).

The maximum moment of the sag portion $= \frac{wx^2}{8} = M_c \qquad (16)$

The maximum moment of the overbend is $\frac{-wx}{2}(L-x) - \frac{w(L-x)^2}{2} = M_b \qquad (17)$

If both moments are equal, but opposite in sign

$$\frac{wx}{8} = \frac{wLx}{2} - \frac{wx^2}{2} + \frac{wL^2}{2} - wLx - \frac{wx^2}{2}$$

$$\text{or } O = \frac{wx^2}{8} + \frac{wLx}{2} - \frac{wL^2}{2}$$

$$\text{or } x^2 + 4Lx = 4L^2$$

$$\text{or } x^2 + 4Lx + 4L^2 = 8L^2$$

$$(x + 2L) = 2\sqrt{2}L$$

$$x = 2(\sqrt{2} - 1)L$$

$$L - x = (3 - 2\sqrt{2}),\ L = (3 - \sqrt{8})$$

$$L = .17157L \qquad (18)$$

About the Author

Noah Roads, engineer with Tennessee Gas Transmission Company, Houston, is a graduate of Ohio State University with a B.S. degree in mechanical engineering. After joining TGT in 1950, he served in several capacities in the field. In September, 1955, he was transferred to Houston to his present position.

Therefore, if $\frac{2M_b}{wL^2}$ is less than $(3 - \sqrt{8})$, the maximum moment is in the sag and can be calculated from Equation 17.

Another useful formula derived from the same conclusions is the depth that the pipe can be lifted with certain negative buoyancy.

$$Y = \frac{3EI}{wR^2}$$ Using same units as before. (19)

Pipe, A Statically Indeterminate Structure. For the launching shoe method the same formulas give good approximations, but the moment of inertia would be for the entire structure. In the point support method and the launching shoe method, the pipe has to be considered as a statically indeterminate structure.

In proposals using the point support method, the loading diagrams were integrated graphically to determine their accuracy. The equations for checking or designing are

$$M_a = M_{fa} - \frac{2EI}{L}\left(2\Theta_a + \Theta_b - \frac{3y_b}{L}\right) \qquad (20)$$

$$M_b = M_{fa} - \frac{2EI}{L}\left(2\Theta_a + \Theta_b - \frac{3y_b}{L}\right) \qquad (21)$$

$$M = M_a + V_{ab}x - \frac{wx^2}{2}$$

These equations can be used for the whole pipe or between any two supports.

In the study all proposals submitted were analyzed but particular interest was shown in the negative buoyancy method. Since analysis of the launching shoe method seems to give good results in the stress study, this method appeared to be the most practical.

Buoyancy Spacing Set. Figure 4 illustrates the laying of 12.750-inch O.D. x .344-inch W.T. pipe, weight in salt water 43.63#/ft. with 1,770# buoys spaced on 43.3-foot centers. Depth of water is 55 feet. Launching angle shown on drawing was 11°-30′, and a minimum radius of 1,124 feet.

The known values are:

$E = 30 \times 10^6$ psi.

$I = 258$ in.

$w = \frac{45.63}{12} - \frac{1,770}{43.3} = .396\#/\text{in.}$

$\Theta_b = .2007$ Radians

$Y_b = 660$ in.

Solve Equation 10 for "L" assuming values until "L" in both terms is within desired tolerance:

$$Y_b = \frac{\Theta_b L}{3} + \frac{wL^4}{72EI}$$

Assuming $L = 3{,}000''$ in $\frac{\Theta_b L}{3}$ and calculate L in other term gives

$L^4 = 646.36 \times 10^{12}$

$L = 5{,}042$ in.

Therefore, L is between 3,000 inches and 5042 inches

Assume $L = 4{,}700$ in first term.

Other term gives

$L^4 = 486.31$

$L = 4{,}696$ in.

Calculate moment from Equation 7

$$M = \frac{2EI\Theta_b}{L} - \frac{wL^2}{6}$$

This gives $M = 7.94 \times 10^5$ in. pounds.

Using Equation 1 $M = EI$

we get $R = 9{,}750$ in. $= 812.5'$.

This analysis indicated that buoy spacing was too wide. So correct buoy spacing was calculated.

Using Equation 13

$L = (12Ry_b + 9R^2\Theta^2)^{1/2} - 3R\Theta$

Substituting known values

$L = 5{,}034$ in.

Using Equation 11

$$w = \frac{72EIy_b}{L^4} - \frac{24EI\Theta_b}{L^3}$$

Substituting known values

$w = .281$ lb./in. $= 3.37$ lb./ft.

Buoy spacing should be 41.9′.

Moments Between Supports Calculated. Figure 5 shows proposed method for laying 26-inch O.D. x .500 W.T. pipe in 50 feet of water. This was designed for minimum radius of 2,040 feet. The supports were buoys with ballast chambers.

In checking this proposal, the moments were calculated from the free end and moment diagram plotted. This diagram was integrated graphically to determine angular deflection; the angular deflection diagram was integrated graphically to determine linear deflection.

At "O" the moment would be nearly zero, because the pipe is essentially straight on the bottom to the

Continued on Page 68

TENNESSEE GAS TRANSMISSION COMPANY

COMPRESSOR CYLINDER DATA

1-10
IDENTIFICATION

DATE: _____ COL. 66-71

CARD #10 COL. 79-80

11-14	15-18	19-22	23-26	27-30	31-34	35-37	38-40	41-42	43-45	46-47	48-50	51-53	54-57	58-61	62-65
OPER. H.P.	CODE	DISC #1 PSIG	DISC #2 PSIG	DISC #3 PSIG	DISC #4 PSIG	R-MIN	R-MAX	INCR-R	K WF	TEMP	R.P.M.	D OF ROD	D OF PIST.	L OF STROKE	FIXED CLEAR
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X.XX	X.XX	.XX	X.XX	X..	XXX	X.XX	XX.XX	XX.XX	XXXX

CODE
$X_1 X_2 X_3 X_4$

AN 8 IN POSITION X_1 WILL COMPUTE VOLUME FOR P_S=100 P.S.I.A.
AN 8 IN POSITION X_2 WILL COMPUTE VOLUME FOR GIVEN DISCHARGE PRESSURES.
AN 8 IN POSITION X_3 WILL COMPUTE H.P. FOR GIVEN DISCHARGE PRESSURES.
AN 8 IN POSITION X_4 WILL COMPUTE POINTS ON OPERATING CURVE FOR GIVEN HORSE POWER
IF AN 8 IS NOT USED, USE A 9.

ADDITIONAL CU. IN. CLEARANCE FOR POCKET POSITIONS

11-14	15-18	19-22	23-26	27-30	31-34	35-38	39-42	43-46	47-50	51-54	
	POCKET #2	POCKET #3	POCKET #4	POCKET #5	POCKET #6	POCKET #7	POCKET #8	POCKET #9	POCKET #10	POCKET #11	CARD #
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
0000											11 IN COL. 79-80
POCKET #12	POCKET #13	POCKET #14	POCKET #15	POCKET #16	POCKET #17	POCKET #18	POCKET #19	POCKET #20	POCKET #21	POCKET #22	
											12 IN COL. 79-80

REMARKS: _____

REQUESTED BY _____

FIGURE 1—Basic compressor cylinder data is supplied in this form. Prior to development of computed daily compressor reports a machine computed performance curve and operating curve was made for each type engine at TGT stations.

How TGT Uses Computers to Analyze Compressor Station Operations

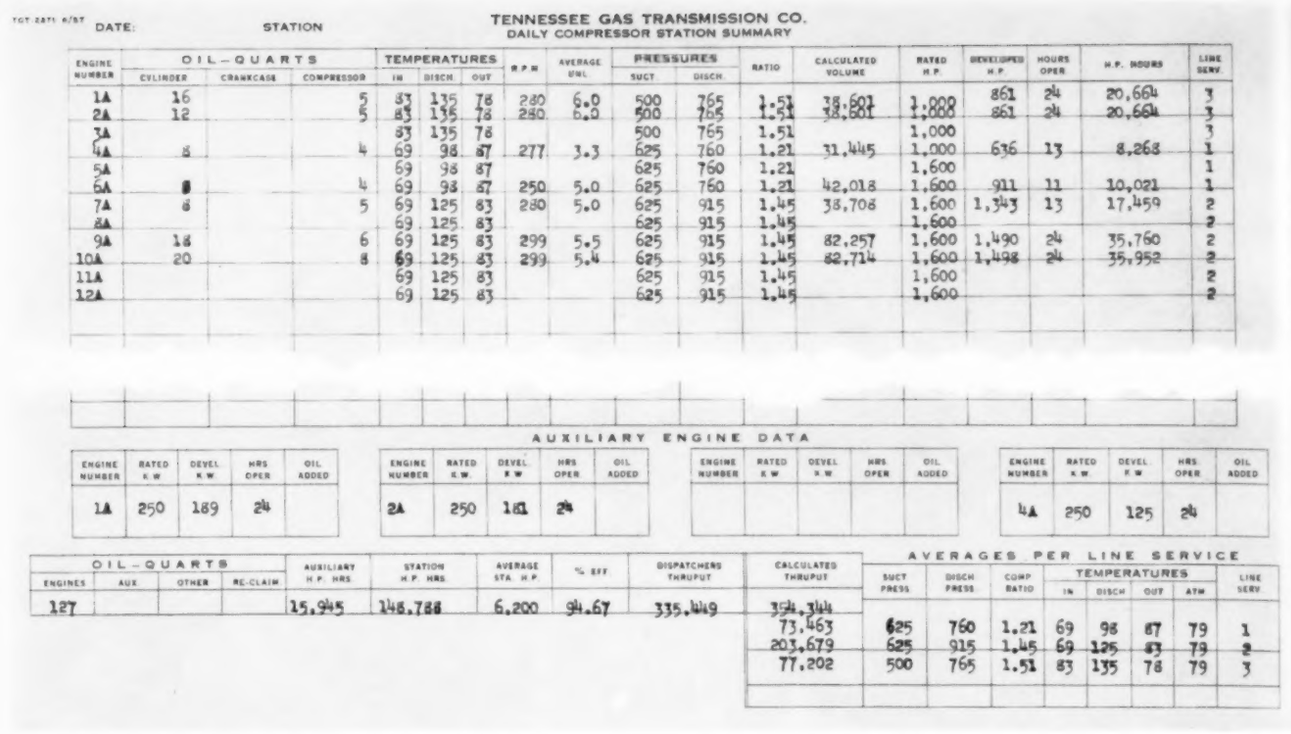
Complete and verified monthly summaries greatly increase operating management's knowledge about key details of compressor operation and maintenance

By John T. Manry, III
Operations Computer Planner
Tennessee Gas Transmission Co., Houston

ON A GROWING gas pipe line system such as Tennessee Gas Transmission Company's, there is a continuing need for detailed compressor engine operating information. Operating management control of the performance and maintenance of more than 500 compressor units required accurate, daily reports in a form that can be readily evaluated.

A medium sized electronic computer has been supplying such information daily at TGT several months. Equipment operating data previously obtained by periodic sampling, is being collected, verified and presented in an understandable form by a computer team on a routine basis. Monthly reports that were formerly verified and balanced by comptometer operators do not need to be checked after being processed through the computer system.

Electronic computer reports increase operating management's knowledge of current operation and maintenance of station equipment. Quick answers are supplied to aid in pipe line design, operation, planning and parts studies.



TGT 2471 6/57 DATE: STATION

TENNESSEE GAS TRANSMISSION CO.
DAILY COMPRESSOR STATION SUMMARY

ENGINE NUMBER	OIL-QUARTS CYLINDER	CRANKCASE	COMPRESSOR	TEMPERATURES IN	DISCH.	OUT	R.P.M.	AVERAGE UNL.	PRESSURES SUCT.	DISCH.	RATIO	CALCULATED VOLUME	RATED H.P.	DEVELOPED H.P.	HOURS OPER.	H.P. HOURS	LINE SERV.
1A	16		5	83	135	78	280	6.0	500	765	1.51	38,601	1,000	861	24	20,664	3
2A	12		5	83	135	78	280	6.0	500	765	1.51	38,601	1,000	861	24	20,664	3
3A				83	135	78			500	765	1.51		1,000				3
4A	8		4	69	98	87	277	3.3	625	760	1.21	31,445	1,000	636	13	8,268	1
5A				69	98	87			625	760	1.21		1,600				1
6A	8		4	69	98	87	250	5.0	625	760	1.21	42,018	1,600	911	11	10,021	1
7A	8		5	69	125	83	280	5.0	625	915	1.45	38,708	1,600	1,343	13	17,459	2
8A				69	125	83			625	915	1.45		1,600				2
9A	16		6	69	125	83	299	5.5	625	915	1.45	82,257	1,600	1,490	24	35,760	2
10A	20		8	69	125	83	299	5.4	625	915	1.45	82,714	1,600	1,498	24	35,952	2
11A				69	125	83			625	915	1.45		1,600				2
12A				69	125	83			625	915	1.45		1,600				2

AUXILIARY ENGINE DATA

ENGINE NUMBER	RATED K.W.	DEVEL K.W.	HRS OPER	OIL ADDED
1A	250	189	24	

ENGINE NUMBER	RATED K.W.	DEVEL K.W.	HRS OPER	OIL ADDED
2A	250	161	24	

ENGINE NUMBER	RATED K.W.	DEVEL K.W.	HRS OPER	OIL ADDED

ENGINE NUMBER	RATED K.W.	DEVEL K.W.	HRS OPER	OIL ADDED
4A	250	125	24	

OIL-QUARTS ENGINES	AUX	OTHER	RE-CLAIM	AUXILIARY H.P. HRS.	STATION H.P. HRS.	AVERAGE STA. H.P.	% EFF.	DISPATCHERS THRUPUT	CALCULATED THRUPUT
127				15,945	148,788	6,200	94.67	335,449	354,344

AVERAGES PER LINE SERVICE

SUCT PRESS	DISCH PRESS	COMP RATIO	TEMPERATURES IN	DISCH	OUT	ATM	LINE SERV.
73,463	625	760	1.21	69	98	87	79	1
203,679	625	915	1.45	69	125	83	79	2
77,202	500	765	1.51	83	135	78	79	3

FIGURE 2—A computed Daily Compressor Station Summary is completed for each station. Data compiled on this form covers the operation of each engine; comparisons may be made quickly between all engines listed on the form. Calculated volumes and developed horsepower were formerly calculated manually from individual engine performance curves. Compression ratio and horsepower hours are computed values for each engine. Possible recording errors by operators will be detected during a cross check of entries.

Early results with the computer analysis program at TGT points toward many possible future benefits. For example, it may be possible to determine:

- Most efficient combination of engines to run at a given station
- Optimum loading conditions for a group of stations on the line
- Best time to renew major parts, such as crankshafts, from operating hour data
- Quantities of spare parts to be stocked in station warehouses
- Most practical location on the system for large, expensive compressor spare parts.

Setting Up the Program. Before starting the actual electronic computer programming, representatives of TGT's Compressor department and systems and data processing department made a joint study of station operating records and reports. An "Electronic Computer Planning Group" was formed to carry out the study. First, a thorough survey was made of all compressor station reports compiled at field locations and in the main office.

Computers Cut Report Deadtime. During the study the group found that some of the information being submitted to the main office routinely from all stations was of little real value to anyone there. Such information as "starting air pressure maintained in the station" would not be useful in data processing or computing. Many of the entries appearing on the Daily Compressor Report serve primarily as a check-off list. To save mailing weight and paper handling in the main office, only that information useful as a permanent record was submitted by the stations for data processing.

As reports were being handled previously it required several man-hours to average and total the daily compressor data for stations having as many as 40 engines. Additional time was often spent to make numbers balance and enter them on the Monthly Station Summary. The main office Comptometer section verified data and made corrections on the monthly report where necessary.

One report that was somewhat difficult to calculate was the Monthly Station Efficiency Report; this involved computation of the amount of gas compressed by each engine type from performance curves and dividing the total of all the gas computed for each engine by the gas compressed by the station. The latter value was furnished by the Gas Control department.

In making this calculation, one day of the month was chosen for each station. An attempt was made to pick the day with steady flow; calculations became quite involved when there was engine switching and unloader pocket changing as a result of large pressure variations.

Another report that consumed a lot of time was the Engine Repair and Down Time Report. In it approximately 35 engine repair categories, including miscellaneous ones were entered to account for repair time. Field personnel compiled a monthly report from which the main office made studies of parts usage by engine type and manufacturer. One study made under this system was that of compressor valve replacement; this was developed through the computer section into a report showing valve breakage by valve types and materials.

How Computer Reports Are Prepared. From the Daily Compressor Station Reports, source data is key punched and fed into the computer along with a large volume of fixed master card data. In the finished report entries are shown for each engine

listing horsepower hours, calculated volume, oil use, repairs and various operating conditions. Different types of compressor engines may then be compared according to their loading conditions, compressing capability and parts usage.

Before inauguration of the computed Daily Compressor Report, a machine computed performance curve and operating curve was made for each type engine at the stations. Basic cylinder data supplied to the computer group was used to compute the swept volume using a compressor formula; this procedure supplied all of the points necessary for plotting performance and operating curves.

Daily Compressor Summary. Computed information about the operation of each engine is listed in the Daily Compressor Station Summary; comparisons may be made at a glance between engines. The computed volume and developed horsepower entries were previously calculated manually from engine performance curves. Compression ratio and the horsepower hours are the other computed values for each engine. Additional information for individual engines is picked up from the source on the compressor station forms.

In reviewing the computed report of a compressor station known to be operating at full capacity, it would be of interest to know the hours that each engine ran and the horsepower that each developed. For example, a field superintendent may have called attention to the need for a special overhaul due to poor performance of a specific engine; this report helps develop a better mental picture of this engine situation.

The lower part of the Daily Compressor Station Summary shows oil consumption for the engines, auxiliary engines and other station usage, as well as volume of reclaimed oil. Also summarized are station horsepower hours and calculated throughput; average station horsepower is computed from the addition of developed horsepower for each engine. To compute station efficiency the printed out dispatcher's throughput is divided by calculated throughput. Actually, this efficiency number is based on the volume computed at the temperatures, pressures, rpm and loading conditions written down on the log sheet, divided into the amount of gas the dispatcher has calculated going through the station.

Detection of Field Errors. During the study some concern was voiced about the possibility of operators writing down favorable numbers to influence station efficiency; however such "errors" can be readily detected. If engines were run at a faster rpm than that recorded, the efficiency number would be higher; showing more pockets open than actually are open on the engine raises the number of the station efficiency. Those numbers that would increase station efficiency by an erroneous entry would show a smaller developed horsepower for the engine than was actually produced. By noting that developed horsepower was not up to par, a check of the compressor operating curves would show that the unloader pocket was set for the proper loading; this would be especially noticeable during a period when the station expected to give maximum performance.

Number of the line service is shown at the extreme right hand of the daily

TGT 2292 R/57

TENNESSEE GAS TRANSMISSION CO.

MONTHLY COMPRESSOR STATION SUMMARY

STA 210 MONTH 02-58

Engine No.	Hrs. Oper.	Hrs. Yr. to Date	Horse Power Hours: This Month	Horse Power Hours: Yr. to Date	Oil–Quarts per 24 Hrs.: Cyl.	Oil–Quarts per 24 Hrs.: C.C.	Oil–Quarts per 24 Hrs.: Comp.	Total Oil–Qts.: This Mo.	Total Oil–Qts.: Yr. to Date	H.P. Hrs. per Gal.: This Mo.	H.P. Hrs. per Gal.: Yr. to Date	Avg. R.P.M.	Rated H.P.	Devel. Avg. H.P.
1A	244	804	289,180	842,623	1.2	9.8	3.0	143	720	8,033	4,681	323	1,320	1,185
2A	473	1,105	530,746	1,162,967	1.3	40.6	3.6	595	1,716	2,369	2,711	318	1,320	1,122
3A	648	1,231	701,556	1,289,982	1.1	23.7	2.6	741	1,292	3,792	3,994	317	1,320	1,083
4A	543	1,214	603,026	1,260,558	1.2	30.9	1.5	760	1,444	3,174	3,492	318	1,320	1,111
5A	617	1,205	666,362	1,225,002	1.2	20.2	2.6	618	1,228	4,299	3,990	318	1,320	1,080
6A	622	1,210	674,865	1,251,775	1.1	29.3	2.8	862	1,799	3,124	2,782	317	1,320	1,085
7A	598	1,232	630,330	1,243,501	1.4	8.0	3.3	316	621	7,979	6,066	316	1,320	1,054
8A	505	967	573,542	1,019,965	1.1	27.6	2.6	657	1,182	3,497	3,446	320	1,320	1,136
9A	540	979	573,530	1,018,412	1.0	.9	5.0	155	373	14,706	10,951	317	1,320	1,062

AUXILIARY ENGINE DATA

Engine No.	Rated K.W.	Avg. K.W.	Hours Oper.	Peak Day	Oil–Gals.
1A	260	175	341	6	38
2A	260	164	281	24	7
3A	260	167	50	1	6

MONTHLY STATION DATA

Total Oil – Gallons: Engines	Aux.	Other	Reclaim	Auxiliary H.P. Hrs.	Station H.P. Hrs.	Avg. Sta. H.P.	% Eff.	Dispatchers Thruput	Calculated Thruput	Averages per Line Service: Suct. Press.	Disch. Press.	Comp. Ratio	Temperatures: In	Temperatures: Disch.	Temperatures: Out	Temperatures: Atm.	Line Service
1,287	50			160,253	5,243,137	7,802	97.77	24,624,095	25,191,043								
NEW OIL	1,337						PEAK DAY	7	979,429	25,191,043	634	767	1.20	79		65	83	1

NEW OIL = ENGINE OIL + AUX. OIL + OTHER OIL – RECLAIM OIL

FIGURE 3—Information from Daily Compressor Station Summary is presented on a Monthly Compressor Station Summary; the monthly report also shows year-to-date figures brought forward. Data not included on other reports includes; peak day that auxiliary engines operated and peak day according to dispatcher's throughout for highest amount of gas compressed during the month.

TENNESSEE GAS TRANSMISSION CO.

ENGINE REPAIR ANALYSIS

DATE	STA.	ENGINE NUMBER	ENGINE TYPE	PART NO.	QUAN.	NEW, USED, OR RECOND.	CYL. NO.	CODING CAT.	CODING SUB.	CODING MFG.	MAINT. OR REPAIR CODE	TIME
			POWER RINGS-COMPRESSION RINGS									
12-31-57	823	8A	TRA-8	8490400	5	NEW	5	10-01-19			R	.5
12-31-57	823	8A	TRA-8	8490400	6	NEW	6	10-01-19			R	.5
					11*							1.0*
					11**							1.0**
			POWER RINGS-OIL RINGS									
12-31-57	823	8A	TRA-8	148-259E	2	NEW	5	10-02-19			R	3.5
12-31-57	823	8A	TRA-8	148-259E	2	NEW	6	10-02-19			R	.5
12-30-57	823	8A	TRA-8	148-259E	2	NEW	3	10-02-19			R	.5
12-30-57	823	8A	TRA-8	148-259E	2	NEW	4	10-02-19			R	.5
12-30-57	823	8A	TRA-8	148-259E	2	NEW	3	10-02-19			R	.5
12-30-57	823	8A	TRA-8	148-259E	2	NEW	4	10-02-19			R	.5
					12*							6.0*

FIGURE 4—Maintenance and repair record sheets are processed monthly; data is then summarized on an Engine Repair Analysis Report. From these studies, comparisons may be made between repairs by engines, engine type, stations, categories, subcategories or engine manufacturer. In this way, it should be possible to determine such things as most serviceable spark plug for a given type of engine simply by comparing quantities used over length of time.

summary page. It is a one-digit code designating which suction line is compressed to a certain discharge line. For instance, line service one is generally the main line suction pressure compressed to the main line discharge pressure. Some stations may have split suction pressure and others split suction and possibilities of split discharge.

It is also possible during a day for an engine to operate on more than one line service. When this occurs, conditions applying to that part of the time on a particular line service are tabulated separately.

TENNESSEE GAS TRANSMISSION CO.

ENGINE AVAILABILITY AND DOWNTIME REPORT

STATION 823
MONTH 12-57

ENGINE NUMBER	ENGINE TYPE	TOTAL CATEGORY DOWN TIME	TOTAL REPAIR DOWN TIME	TOTAL UNAVAILABLE TIME	REPAIR TIME PER MILLION H.P. HOURS	% OPERATED	% AVAILABLE	LOAD FACTOR—%
1A	HBA-6	15.6	15.3	15.6	25.8	68.55	97.90	88.25
2A	HBA-6	4.3	2.3	18.3	2.8	96.37	97.54	88.00
3A	HBA-6					97.31	100.00	89.24
4A	HBA-6	1.8	1.8	1.8	2.1	95.97	99.76	91.46
5A	HBA-6	21.0	20.2	50.2	27.8	79.57	93.25	92.91
6A	TRA-8	17.3	17.3	49.3	19.1	85.62	93.37	98.04
7A	TRA-8	35.7	35.5	67.5	85.4	40.46	90.93	95.82
8A	TRA-8	19.1	18.1	49.1	19.6	87.37	93.40	97.96
9A	TRA-8	10.8	10.9	29.9	12.3	83.60	95.98	98.15
*	HBA-6	42.7	39.6	85.9	10.2	87.55	97.69	89.96
*	TRA-8	82.9	81.8	195.8	26.1	74.26	93.42	97.66
		125.6	121.4	281.7	17.3	81.34	95.69	93.25

FIGURE—5—Computed information on Engine Availability and Downtime Report is shown by station. To make a complete repair analysis for a particular engine part, percent load factor should be considered. From these reports it may be possible to determine optimum load factor for the best service of such large parts as crankshafts, power cylinders and power pistons.

The lower right hand corner of the daily report shows average pressures, compression ratio and average temperatures for each line service. This amounts to an average for a station when there is only one line service possible.

Auxiliary engine data is also published on the lower part of the Daily Compressor Station Summary. This includes for each engine; rated kw, developed kw, hours operated and quantity of oil used. One of the first results made in the computer study was achieved using this data; the developed kw was added for various units and checked to see if a smaller number of units could be used to carry the electrical load.

Monthly Station Summary. The Monthly Compressor Station Summary is primarily a totaling and averaging of the daily summary figures; it includes also some year to date figures brought forward. For each engine, entries are made of the hours operated, hours operated year to date, horsepower hours operated current month and year to date, oil consumption rates in quarts per 24 hours for cylinders, crankcase and compressor cylinders. Also listed are total oil used in the month and year to date, horsepower hours per gallons for the month and year to date, average rpm, rated horsepower and developed average horsepower.

Basic information is therefore provided for each engine on its usage, loading and oil consumption. On the lower part of the sheet, the monthly summary shows a monthly recap of all daily compressor station summary data. In fact, the only data that is different on the monthly report is the peak day the auxiliary engines operated and the peak day according to dispatchers throughput which shows highest amount of gas compressed during the month.

Compressor Efficiency Report. Entries on the Monthly Report of Compressor Efficiencies are identical to those found on the monthly compressor summary. This report lists all stations showing their average efficiency for the month. Dispatchers throughput and calculated throughput figures are printed out for information.

Should there be a reason to verify the efficiency, it is possible to check back through the dispatcher's records and examine the conditions under which the values of the throughput were computed. A good way to analyze this report is to make comparisons between the current month and previous months, noting magnitude of the changes. Any trend downward on any particular station would make it worthwhile to investigate the cause and, if possible, get the trend reversed.

Analyzing Engine Repairs. An Engine Repair Analysis Report is prepared monthly for each compressor station. To produce it the Maintenance and Repair Record Sheets are processed monthly. A normal run consists of listing all repairs for a station by repair categories and sub-categories in engine number order; time spent for each repair is summarized within sub-categories by engine type.

For special studies, comparisons may be made between repairs by engines, engine types, stations, categories, sub-categories and engine manufacturers. It should be possible to determine the most serviceable spark plug for a given type of engine simply by comparing quantities used for each manufacturer over a certain length of time. Engines using the most pistons would be worth examination, or such items as the quantity of rings used on the various engines and engine types.

Availability and Downtime Studied. The Engine Availability and Downtime Report shows for each station engine type, total downtime of all categories, total repair downtime, total unavailable time, repair time per million horsepower hours, percent operated, availability and the load factor.

To make any complete repair analysis for a particular engine part, the percent load factor should be considered. For instance, ring wear of an engine running at a 98 percent load factor would be somewhat different from an engine running at 75 percent load factor. It is hoped that in time it will be possible to determine the optimum load factor for the best service of such large engine parts as crankshafts, power cylinders and power pistons.

What Field Data Is Needed? One of the rigid requirements of electronic computed reports is that the source data coming in from the field must be in such form as to be easily key punched. There is a series of built-in automatic checking features in the program to detect out of line numbers, but a poorly averaged number may not show up until a visual inspection is made of the reports sent back to the field.

For example, an unloader pocket column may have been added wrong, causing a horsepower operated figure to be somewhat over the horsepower rated figure on a compressor engine. This type of error would probably be spotted in the field, and a check would indicate the erroneous source data number, necessitating a correction to the stored punched cards in the Data Processing department.

There is some difficulty experienced in writing the rules for the operators and repairman to code the engine repairs properly. Much research should be given to any system of coding repairs and downtime. The more categories and subcategories that coding can be broken down into, the more valuable information computer reports will present. However, the more coding that has to be done by the field maintenance men, the more will be the chance of errors, causing re-runs

ACKNOWLEDGMENT
From a paper presented at the ASME, Petroleum division, Mechanical Engineering Conference, Denver, Sept. 21-24, 1958.

About the Author

John T. Manry, III, operations computer planner, Tennessee Gas Transmission Company, has been active in the development of that company's electronic computer planning group and in its study of compressor station operations. A mechanical engineering graduate of the University of Texas, Manry has completed assignments in TGT's Operations and Gas Control departments after a tour as results engineer at compressor stations. His naval service in World War II included engineering assignments on several vessels and chief engineer of auxiliary types. Manry is a registered professional engineer in Texas and is active in the ASME and other engineering and scientific groups.

Part 2—Influence of Design Factors

Lengthen the Life of Antifriction Bearings

Each type of bearing is designed to do a specific job in rotating machinery. Consider these design features during installation and maintenance to obtain top performance

By Johnny Riddle
Allied Bearings Supply Company, Tulsa

IN THE INSTALLATION and maintenance of bearings on pipe line construction machinery or station equipment, certain design factors and unit modifications should be considered carefully. Once these design features are understood, many ideas for better maintenance will follow naturally.

Space will not permit the full discussion of every modified or related bearing design here—there are literally hundreds of them—but basic types will be presented. Many principles of performance are closely related to all *rolling* bearings, both ball and roller, so it follows that characteristics of the parent type will be found in modified units too, to some extent.

For example, a basically rigid type bearing may not be subjected to more than nominal misalignment, whether it is a sealed, shielded, or open type design. Similarly, a unit designed with internal self alignment features may not be safely subjected to more than moderate thrust loads.

Rather obviously, those bearings which use a *rolling* element for load-carrying are one of two designs—ball or roller. Nomenclature of a typical ball bearing is shown in Figure 1.

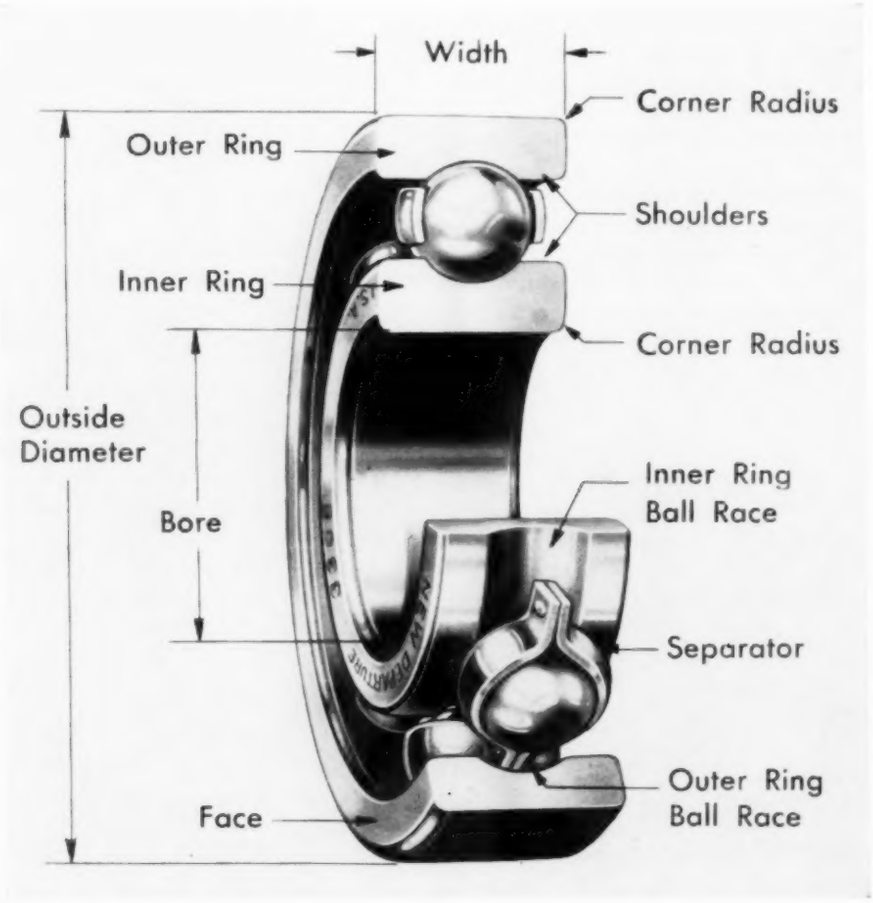


FIGURE 1—Cutaway drawing shows various parts of typical ball bearing with the proper nomenclature given to each.

FIVE BASIC BALL BEARINGS

While the ball bearing industry offers the machinery builders a choice of literally hundreds of sizes, practically all production centers about five basic designs. As shown in Figure 2, these are: (1) single row radial, (2) double row, (3) radial-thrust, (4) internal self-aligning, and (5) thrust. The other seven units shown are merely modified types.

Now consider the basic ball types and their intended service functions:

Single Row Radial. The most popular of all ball bearing deigns, it is symmetrical in design and assembly, and accommodates a wide range of load variations. Evolving from a common bore size, extra-light, light, medium and heavy series are produced. The *K* type shown is elsewhere known as the deep groove design, and the term Conrad is also applied to it.

Similar to the deep groove radial, but assembled with more balls for increased radial capacity, is the "maximum capacity" single row radial, listed in the illustration as *W* type. Loading slots formed in the rings tend to restrict thrust capacity (some axial displacement of rings develops when bearings operate under thrust loads)

and the permissible speed range is reduced.

These two units, particularly the deep groove radial, are available in numerous seal-shield-snap ring variations.

Double Row Rigid. This unit generally appears when heavy radial, thrust, or combined machine loads are present. If designed on radial principles, the unit is actually similar to two single row bearings. However, contact lines are usually of diverging or converging nature. The two ball assemblies normally feature individual cages or retainers.

It is also available in shielded and snap-ring variations, even occasionally with positive seals. The user will of course identify this unit as a companion bearing in many pump mountings, where it opposes a duplex set.

Internal Self-Aligning. This bearing is recommended for light to moderate radial and light thrust loads. The wider series have increased thrust capacity.

These bearings have two rows of balls which roll on the spherical surface of the outer ring. They compensate for slight angular shaft misalignment resulting from errors in mounting, shaft deflection under load, distortion of the foundation, or other machine irregularities.

When designed with a tapered bore, this unit is often fitted with an adapter assembly for use on straight shafts. Many such modified units are used in pillow block assemblies.

Because of the inherent self-aligning features designed into it, the internal self-aligning bearing is not produced with seals or shields. However, it is manufactured in different series.

Radial-Thrust. Recommended for heavy thrust combined with radial loads, it must not be mounted with loads passing through the shallow ring shoulder. All radial-thrust (angular contact) bearings are designed with some inherent "slop" or internal looseness. This must be removed by some principle of mounting. Locknuts, springs, spacing members and similar devices are employed for this purpose.

Men engaged in pump maintenance will remember the use of this unit when two of them are used for a duplex mounting. Three duplex arrangements are common:

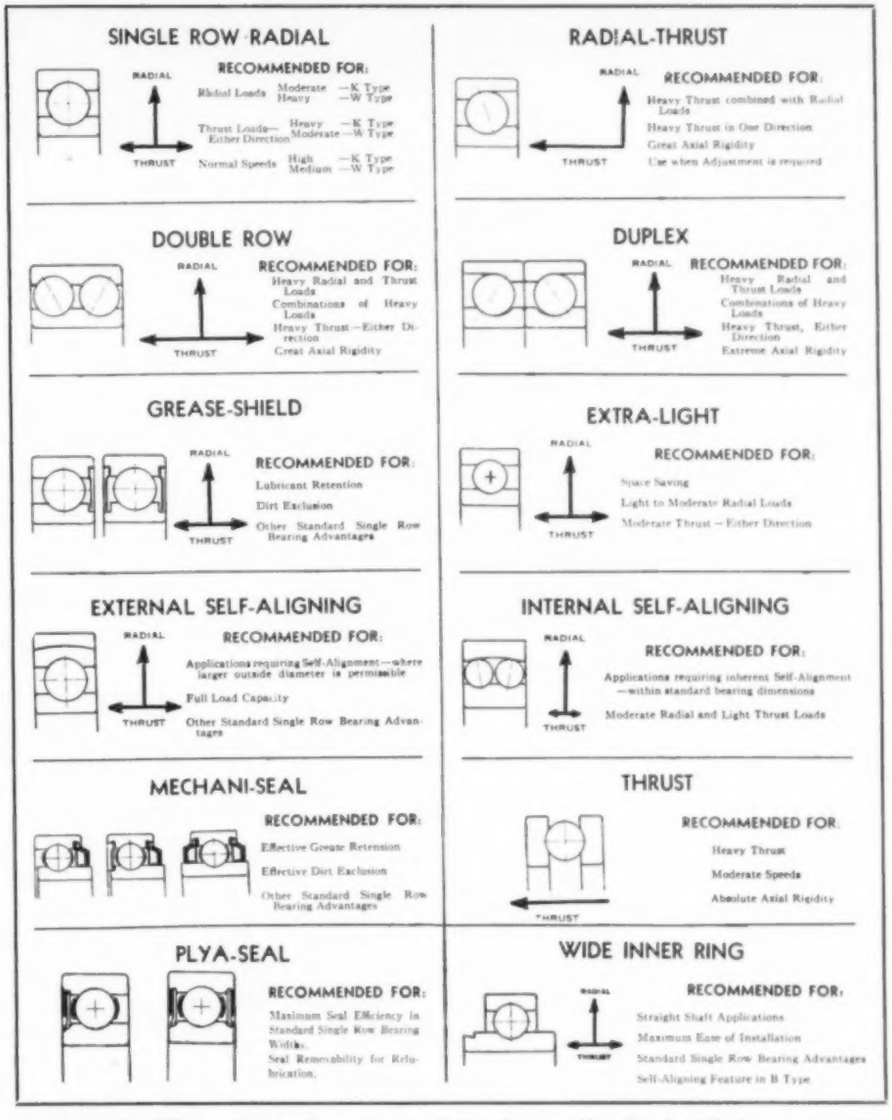


FIGURE 2—These charts show types of bearings ordinarily installed on pipe line rotating equipment. Consideration of their radial and thrust handling characteristics is important in getting good operation. Ability to take radial or thrust loads determines the recommended services for each type bearing.

These arrangements have operating characteristics as follows:

1. DF, or face-to-face—provides rigid location against radial or thrust loads. It is less sensitive to misalignment than the DB or DT styles.

2. DB, or back-to-back (Figure 2 unit in DB position)—provides good radial location, and allows the bearing assembly to float when this is a design requirement.

3. DT, or face-to-back—provides extreme thrust capacity in one direction.

These units are widely used in pump applications—particularly the DB and DF—watch for these operative difficulties when they are improperly reversed in the mounting:

- If mounted DB instead of DF, bearing may not take care of misalignment.
- If mounted DF instead of DB, bearing may not lend desired rigidity to the shaft.
- If mounted DF (with outer rings floating) instead of DB, the bearing may be loose and have no preload when assembled in position.
- If mounted DT in wrong direction, the bearing may support excessive thrust loads against the counterbore (low shoulder side) and failure will result.

Thrust (or flat thrust bearing). Recommended for absolute axial rigidity it carries light to heavy thrust loads at slow to moderate speeds.

Designed for uni-direction thrust only (two-direction bearings use a second ball-cage assembly with additional ring), the bearing's load line through the balls is parallel to the axis of the shaft, resulting in high

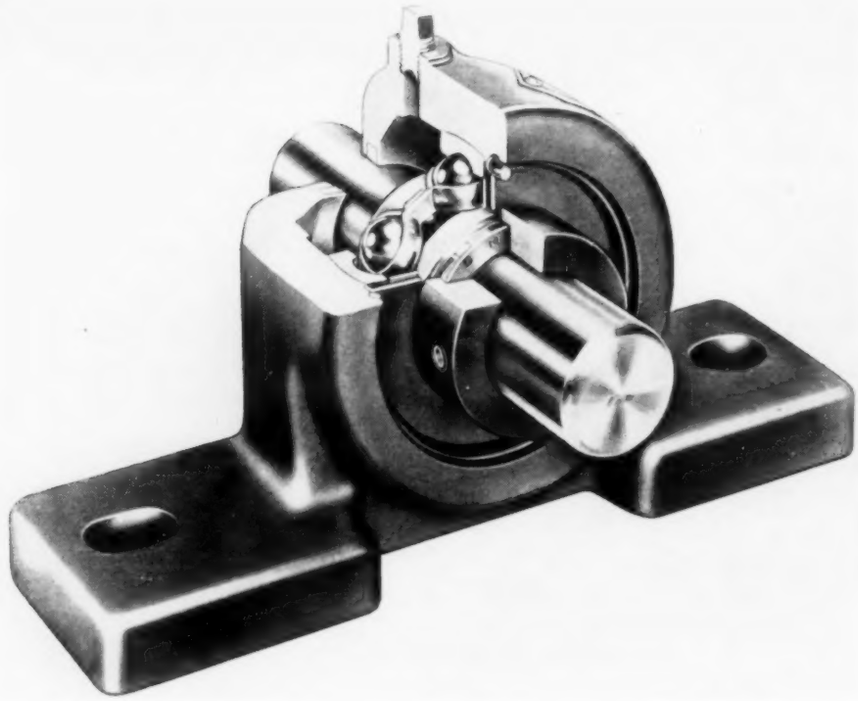


FIGURE 3—Partial cutaway of a ball bearing pillow block shows its design features. Related in principle to the single-row radial, load capacities for the various block designs are approximately the same as those for standard bearings of similar size and type.

FIGURE 4—Tapered roller bearings are often recommended for radial thrust or angular loads. By changing dimensions or angles of the rolling elements, the bearing can be designed for a wide variety of services. When severe thrust loads are met, designers may consider a steep-angle bearing; in this case only the angles of the unit assembly are changed.

thrust capacity and minimum axial deflection.

This is the simplest of the ball thrust bearings, yet it is adaptable to many mountings requiring great thrust capacity. When good alignment can not be maintained, the bearing may be fitted with a spherical or self-aligning seat washer. Unless internally modified, flat thrust bearings are limited to moderate speeds.

Transmission Appliances, Ball Bearing. A variety of so-called power transmission units are available; of these the ball bearing pillow block shown in Figure 3 is typical.

Though given numerous external modifications, the bearing itself is actually related in principle to the single row radial with wide inner ring shown in Figure 2. Hence we see that load capacities for the various block designs are approximately the same as those associated with standard bearings of similar size and type.

Wherever a small, compact and sealed bearing assembly is needed, the pillow block may be the answer. All of them feature built-in alignability, this feature being achieved by forming the outside surface of the outer ring with a spherical contour (see Figure 2, external self-aligning), or by the use of an internal self-aligning basic bearing which is combined with an adapter assembly.

For shaft location, one of several locking devices may be used: set screws, annular or eccentric collars with set screws, and adapter sleeves coupled with nut and washer. Related appliances include flange and cartridge units, takeups, hanger boxes and

FIGURE 5—Cylindrical roller bearings are suited to high radial loads at either low or high speeds. They operate well under conditions requiring both capacity and rigidity in restricted space. Rollers are well guarded by advanced separator design. Such bearings are not well adapted to thrust loads but are often selected where a thrust type is used in conjunction.

FIGURE 6—Spherical roller bearings are well suited for extremely heavy radial loads with substantial thrust handling ability in either direction. Being inherently self-aligning, angular misalignment between shaft and housing is not detrimental during service. Balanced performance of this unit is to a great extent influenced by built-in radial clearances of the assembly.

others, all employing essentially the same idea in a modified housing.

Manufacturers offer different series in these transmission units. This helps the machine designer select a unit having size and capacity very near what is actually needed.

Another desirable feature of these assemblies is that the bearing can be removed and a new one installed at a cost substantially below the price of the complete unit. Blocks are effectively sealed for lubricant retention and dirt exclusion.

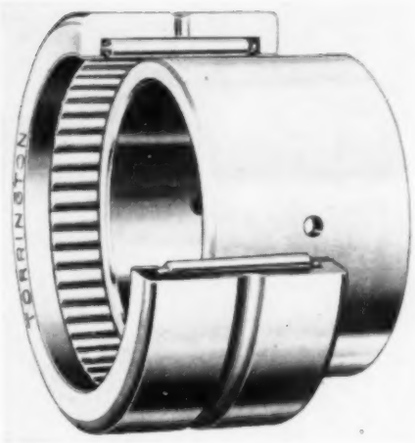
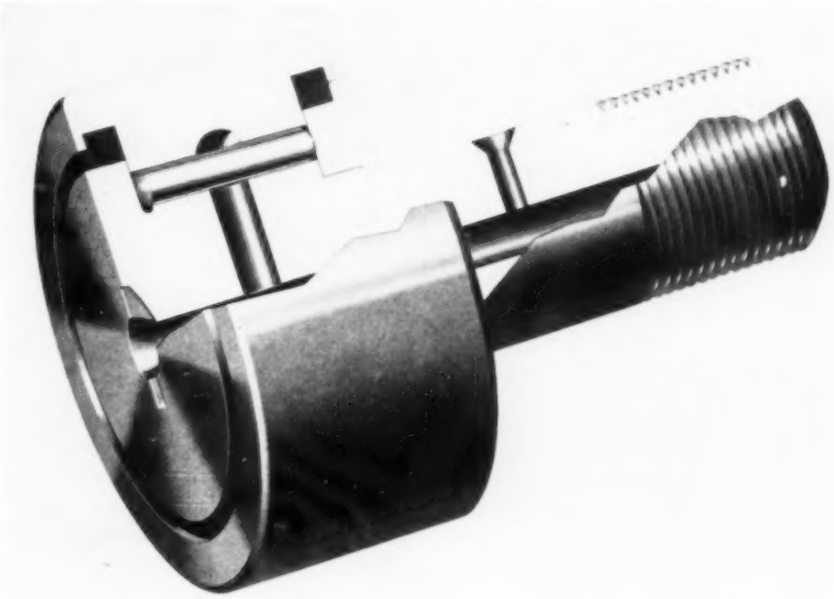


FIGURE 7—(Left) Needle roller bearings perform well under a wide range of speeds. Often called the thin-shell or drawn cup type, it consists of a drawn case hardened shell surrounded by a full complement of precision rollers. The outer shell forms the outside race and rollers operate directly on a shaft or on a finished interior race depending on space usable to the bearing assembly.

FIGURE 8—(Below) For services where a bearing must operate under radial load with cam or track action, the needle bearing cam follower type may be selected. It is designed for specific use as a cam or track roller with an integral stud permitting cantilever mounting. Its heavy outer race withstands heavy rolling and shock loads while giving high capacity antifriction performance. Unit shown features built-in synthetic sealing elements.



ROLLER BEARING TYPES

Tapered Roller Bearing. Often recommended for radial, thrust or angular loads, the tapered roller bearing is an accepted workhorse of industry. It is manufactured in a wide range of designs and sizes, bringing to the designer the specific bearing needed. By changing the dimensions or angles of the rolling elements, an almost endless variety of bearings has been produced. Figure 4 is of a conventional tapered roller design.

This same unit is produced with an integral flange on the outer race or cup. The flange facilitates housing machine work—facing an outside seat at right angles to the bore provides backing for the cup flange and gives excellent location.

When very severe thrust loads are present, the designer may want to consider one of the steep-angle bearings. The fundamentals of tapered roller design are maintained, only the angles of unit assembly are changed.

Multi-row bearings are also available, again in a variety of designs. One assembly, a double cup with single cones, is designed to provide proper running clearance when assembled. Unit is well suited to those mountings where it is not desirable to provide a means for takeup, also for those mountings where a fixed unit opposes a floating one.

Cylindrical Roller Bearing. These units, of which Figure 5 is typical, are suited to high radial loads at low to elevated speeds. They operate extremely well under conditions requiring both capacity and rigidity in restricted space. Rollers are well guided by advanced separator designs.

Again, variations are numerous, and either the inner or outer ring may be separable. Retaining lips may be integral or supplemental. Cage material and design is also intentionally modified when specific service problems must be dealt with. Obviously, such a bearing is not well adapted to thrust loads, but it may be and often is selected for a mounting where one or another of the thrust types is used as a companion bearing.

Some 10 or 12 modified designs are available, to give the user a bearing which will very nearly meet exact requirements.

Spherical Roller Bearing. Shown in Figure 6, this type is well suited to extremely heavy radial loads, with substantial thrust capacity in either direction. Resulting from the number, size and shape of the rollers, spherical bearings are unexcelled for capacity. Inherently self-aligning, angular misalignment between shaft and housing has no detrimental effect on their performance. Full capacity is always available for useful work.

This unit is also made in tapered bore construction, when it uses an adapter assembly with locknut and washer for mounting. In this manner it is often applied to heavy-duty pillow blocks.

Balanced performance of this unit will to a great extent be influenced by the built-in radial clearances contained in the assembly. This is a critical variable of design, and the user should bear this feature in mind when replacement bearings are selected.

Needle Roller Bearing. These units are well suited to radial loads under a wide range of speeds. A very wide range of types and series has been produced, of which Figure 7 is only one.

A very popular unit is the so-called thin shell or drawn cup type. It con-

FIGURE 9—For severe axial loads with uni-direction thrust and good alignment, machine designers often select a single-acting roller thrust bearing. One of the simplest thrust bearings produced, it is very practical when space is limited and loads are heavy.

FIGURE 10—(Right) Heavy duty spherical roller bearing pillow blocks provide a capacity about the same as that of a similar unit mounted in the standard housing. Four bolt construction, shown here, gives excellent resistance to all machine loads. Piston ring seals retain lubricant and exclude contaminants.

sists of a drawn, case-hardened shell, surrounding a full complement of precision rollers. The outer shell forms the outside race. Rollers operate directly on the shaft or on a finished inner race, depending on how much space the designer wishes to allocate to bearing assembly. The thin shell units have broadened the scope of needle bearing application by eliminating the difficulties of handling and assembly previously associated with loose needle rollers.

The unit shown in Figure 7 consists of a relatively heavier outer race assembly, combined with the maximum number of rollers and an inner race. Properly designed needle bearing mountings represent the ultimate in radial capacity when size and sectional depth are considered.

Modified needle bearing designs include assemblies with center-guides, various separator materials and designs, and some with build-in end seals. In the latter, lip type seals are normally used. For extremely severe loads, multi-row needle bearings may be obtained; many of them with the modified features listed above.

Needle Bearing Cam Follower. When machine designs call for a bearing to operate under radial load with cam or track action, the designer may want to consider the needle bearing cam follower, Figure 8. This unit is designed for specific use as a cam or track roller with an integral stud permitting cantilever mounting.

The heavy outer race withstands heavy rolling and shock loads while giving high capacity anti-friction performance. The unit shown features built-in synthetic sealing elements. A variation of the cam follower design, in which a bearing inner ring replaces the stud, is the cam yoke roller. It also is designed with an exceptionally heavy outer race for cam or track action. Yoke mountings are popular for this design.

Roller Thrust Bearing. Under severe axial loads, when uni-direction thrust is involved and good alignment can be maintained, designers often use a single-acting roller thrust bearing, of the general type shown in Figure 9.

This is one of the simplest thrust bearings produced, yet it is very practical when space is limited and loads are heavy. The same basic bearing is fitted with a self-aligning washer when poor alignment tends to characterize the mounting.

Transmission Appliances, Roller Bearing. The heavy-duty spherical roller bearing pillow block shown in Figure 10 is typical of the numerous units available. Using a conventional spherical roller bearing, the complete block provides a capacity about the same as that of a similar unit mounted in a standard housing. Here, four-bolt construction provides excellent resistance to all machine loads.

Piston ring seals retain lubricant and exclude contaminants. It may be fitted with stabilizing rings for 'held' or 'floating' requirements. It may be applied directly to the shaft, or it may be obtained in tapered bore construction which relies on an adapter assembly for shaft location.

Another popular bearing designed into block assemblies is the concavex unit. It features concave rollers running between convex raceways to form the basic roller design. The inner race is a segment of a true sphere, and is free to move in any direction without altering the contact of the rollers. This feature provides compensation for misalignment and assures normal bearing operation under all conditions.

Many tapered roller bearings are similarly applied. —The End

Don't Bet Your Life on Unsafe Habits

An insurance survey found that in 330 accidents where 30 injuries occurred only one was serious. But unsafe acts and conditions cut down your odds

By **J. A. Gavin**
Tidewater Oil Company, Tulsa

THE NUMBER of on-the-job injuries is appalling. According to National Safety Council statistics, more than 15,000 workers are killed and more than 2 million are injured annually in accidents on-the-job. The suffering and hardships caused by such accidents affect not only the persons involved, but their families as well. When a worker is injured on the job, some loss in earning capacity usually results.

When the accident rate goes up, usually the result of unfavorable accident experience, the company's premium cost of compensation insurance increases. Also, there is an indirect loss because the company's normal operations have been interrupted. For every dollar spent to pay the direct costs of accidents on the job, statistics prepared by one of the nation's largest insurance companies indicates there is an indirect loss of four dollars.

Better Morale. Effective accident control measures promote good employe morale. It is only natural that men are happier and want to work in an organization where the accident rate is low, injuries are few, and a sound, effective accident control program is actively sponsored by management.

Another point to consider is that a good safety record is impressive to customers, employes, and stockholders.

1. Injuries on-the-job do not just happen. An injury is the final link in a chain of events.
2. An accident is an unplanned event and is caused by an unsafe act, unsafe condition or both.
3. Injuries and accidents are the result of unsafe acts or conditions.

Why do people sometimes act unsafely and create unsafe conditions? Several reasons have been suggested, such as:

1. **Don't Care**—The worker may not possess the proper interest in the job.
2. **Don't Know**—The worker may not possess the skill or know-how, to perform the job safely.
3. **Not Able**—The worker may have some physical or mental deficiency, limiting his ability to perform the work safely.

Physical or mental deficiencies may be caused by some background or environmental condition which normally starts outside the job. They include such factors, for example, as home conditions, worries about sufficient money to pay bills or indebtedness, illness, domestic difficulties, inexperience—perhaps he has not been at the work long enough to acquire the experience necessary to perform the job without becoming involved in an accident. Other conditions are personal habits, lack of sleep, too much night life, and poor eating or health habits.

Such defects or imperfections are not controllable by the supervisor, but they do exist to some degree in many people. These defects may involve a second or third party; they are not always caused by or the result of some physical or mental handicap of the injured person.

Let's take a look at a hypothetical case and see how it would apply:

Case Study. A field maintenance electrician's child had fallen seriously ill and may require a surgical opera-

"Out of every 30 injury-producing accidents, 29 require first aid and only one is serious enough to result in lost time or hospitalization. It is possible, therefore, to tell how many injuries will occur in a given period of time in a given situation.

But what does this mean to the man on the job? It means that when an accident is caused by an unsafe act or condition, Lady Luck is in his corner. As exposure to these unsafe acts or conditions continue, Lady Luck slowly begins to desert him.

Eventually she turns away entirely, and the unsafe act or condition results in an injury producing accident."

Common Unsafe Acts

1. ***Operating Without Authority—Failure to Secure; Failure to Warn***
   Operating without authority includes any unauthorized action such as jumping on or off a moving vehicle; operating someone else's equipment without permission; using tools or machinery for which worker has not been trained, etc.
2. ***Operating at an Unsafe Speed***
   Running instead of walking; operating motor vehicles or machinery at an unsafe speed; working too fast or too slow thereby endangering self and others; using shortcuts that are unsafe; throwing materials instead of carrying.
3. ***Bypassing Safety Devices***
   Removing safety devices; blocking, plugging or tying-off safety devices; disconnecting, misadjusting, or failing to secure safety devices; failing to inspect and repair safety devices and ignoring warning signs.
4. ***Using Unsafe Equipment***
   Using defective equipment, such as tools, machinery, or material that has become defective or unsafe; gripping objects insecurely, taking wrong hold of objects or using the wrong equipment or tools for a particular job.
5. ***Unsafe Loading, Placing, Mixing or Combining***
   Unsafe loading on a vehicle, platform, hoist, etc., loading too high or in such a manner as to create a top-heavy or unbalanced load; crowding or unsafe piling; lifting or carrying too heavy loads; parking, placing, stopping or leaving vehicles, elevators and other conveying apparatus in an unsafe position for loading and unloading; leaving oil, water or grease on working surfaces that are required to be clean and dry.
6. ***Taking Unsafe Position or Posture***
   Lifting or carrying loads improperly; walking or working on unguarded beams, girders, scaffolds or platforms; riding in an unsafe position on tractors, trucks or other vehicles; passing other vehicles on grades and curves; standing in line of travel of moving objects; exposure to falling or sliding objects; not using proper methods of ascending or descending; obstructing the free movement of others.
7. ***Working on Moving or Dangerous Equipment***
   Oiling, cleaning, or adjusting equipment while in motion; working on energized equipment without cutting-off electrical power; getting on or off vehicles while they are in motion; burning or welding on equipment, lines, tanks or vessels containing flammable products without first gas-freeing; cleaning and venting, caulking, packing, or hammering on equipment under pressure.
8. ***Horseplay***
   Teasing, abusing, or startling fellow-workers; playing practical jokes, wrestling; quarreling, fighting, shouting, or making unnecessary noises or disturbances.
9. ***Failure to Wear Protective Devices***
   Failure to use personal protective items such as goggles, gloves, safety shoes, gas masks, safety helmets, respirators, face shields, aprons; failure to report defective safety apparel. Wearing of jewelry, unsafe clothing such as long sleeves, loose clothing.

tion (**background**); he reports to work worried and distraught (**personal defect**). He is assigned to crawl under some electrical apparatus to repair a short circuit.

In his distraction he forgets to disconnect or open the circuit and lock out the control-switch (**unsafe act**). While he is working under the equipment, the regular operator, unaware of his presence, closes the switch energizing the circuit sending an electrical current through the repairman (**accident**). The man suffers severe burns and shock (**injury**).

The problem is to stop the action of "injury" and "accident." How can we do that? By locating and removing the weakest link in the chain of events that lead to the accident and resultant injury.

Accidents and injuries are results rather than causes—over which we have no direct control.

Background, personal defects and unsafe acts or conditions are causes One of these links should be removed. Unfortunately, there is not much the supervisor can do about removing **background.** An employe's home conditions, his domestic life and personal habits are not often subject to outside control.

The same is true of **personal defects.** They are not subject to outside control; or at least they can be controlled only with great difficulty, which leaves us with **unsafe acts or conditions.** This link must be removed if we hope to break the chain of events leading to accidents and injuries.

Supervisors Responsibility. Who can best do this? The supervisor. Why? Because he is the individual who deals directly with the workers and is the only one close enough to the job to see unsafe acts and conditions. So, as a representative of management and being closest to the job, he has the opportunity, authority and responsibility to control them.

Fortunately, every unsafe act or condition does not complete the chain of events that leads to or results in an injury-producing accident. We need not guess at the laws of chance controlling injuries. A representative of one of the large insurance companies actually studied and counted thousands of cases and found that according to the law of averages, out of every 330 accidents only 30 resulted in injuries.

Out of the 30 injury-producing accidents, 29 required first-aid and only one was serious enough to result in loss of time or require hospitalization. By using this knowledge of the law of averages as applied to accidents, it is possible to tell in advance approximately how many injuries will occur in a period of time in a given situation.

Ride With Lady Luck. What does this mean to the man on the job? It means that when an accident is caused by an unsafe act or condition, Lady Luck is in his corner. She is favoring him with 10-to-1 odds against having any sort of an injury-producing accident, with 300-to-1 odds against his having an injury requiring hospital treatment.

However, as exposure to unsafe acts or conditions continue, Lady Luck will slowly begin to desert him. Eventually she turns against him and the unsafe act or condition results in an injury-producing accident.

Supervisors must recognize that accident control is an important part of their operating responsibilities. They must see to it that workers avoid risks; and, make certain that unsafe acts and conditions are eliminated wherever possible.

Unsafe Acts. How can supervisors recognize an unsafe act when it occurs? The list presented in the box sets forth the possible categories of human failure that can result in an accident. It is based on a study by the American Standards Association and has been used in many successful accident control programs.

When an Unsafe Act Occurs. What should you do when you observe a worker performing an unsafe act? What is the first step?

1. Stop the action.

2. Investigate (study the job). Check the employe's work methods. He may be performing an unsafe act because he knows no other way of doing the job.

3. Instruct. Once you have decided how the operation can be done more safely, instruct the worker in the correct method. Tell him how to do it, demonstrate it for him, and then let him try it. If the man does the same wrong thing the next day, you should continue the instruction. "If the learner hasn't learned, the instructor hasn't taught."

Common Unsafe Conditions

1. ***Lack of Guards***
   Lack of, or improper guards in hazardous locations such as, platforms, catwalks, and scaffolds where no guard rails are provided; transformer banks that are not properly enclosed, elevated or fenced off; machines and other types of moving equipment where moving or dangerous points are not guarded; lack of shoring in excavation, trenches, construction, etc.

2. ***Inadequate Guards***
   Partially guarded equipment. A worker seeing some sort of guard may feel safe and fail to take precautionary measures he normally would if there were no guards at all.

3. ***Defects of Agencies***
   Rough, slippery, sharp-edged; poorly designed; decayed, worn, frayed or cracked; buildings, machines or tools that are in disrepair or have been condemned.

4. ***Unsafe Design or Construction***
   Machinery, equipment, buildings or facilities that are structurally unsafe due to some error in original planning and construction.

5. ***Hazardous Arrangement***
   Poor housekeeping, which includes oily, dirty, cluttered floors and work areas; congestion of working spaces; inadequate aisle space, exits, etc.; inadequate drainage; overloading; unsafely stored or piled materials, tools, etc.

6. ***Improper Illumination***
   Glare; insufficient light; too much light; unsuitable arrangement producing shadows or contrasts; no light.

7. ***Unsafe Ventilation***
   Concentration of gaseous vapors, dust or fumes; insufficient air changes; impure air source; abnormal temperatures or humidity.

8. ***Unsafe Dress or Apparel***
   Lack of, unsuited or defective shoes; torn clothing, oil-stained or oil-saturated clothing, lack of goggles, safety hats, or face shields; no gloves or mittens, respirators, gas masks, or safety belts; and ill-fitting items of personal protective equipment, defective or not available.

4. Train the worker in the safe job procedure. Check on him from time to time to make certain he understands your instructions. Repeat instructions, if necessary, until you are convinced he is trained and will not fall back into the old, unsafe method.

5. Discipline should be invoked when workers decline to observe the safe practices established for the job.

Application of these principles should reduce accident exposure 50 percent and eliminate 50 percent of the injuries.

It has been stated generally by safety specialists that workers reflect the attitude of their foremen toward safe practices. When you hear a foreman complain that his men pay lip service only to safety rules, he may possibly be overlooking the fact that his own attitude might be the cause. His men may be violating safe practices because they see him doing it.

Many supervisors may think that teaching and enforcing safety principles is not an essential part of their jobs. In cases where an organization shows a poor safety record, the responsibility may be reflected in the attitude of the foremen and supervisors.

Unsafe Conditions. These are often the results of unsafe acts. Those listed

set forth the types of unsafe conditions that may lead to on-the-job accidents and injuries.

Whenever supervisors detect exposures to unsafe conditions, the following corrective measures should be taken.

1. Remove the hazard. If you see a heavy box on the edge of the loading dock where it is likely to fall and injure someone, see that it is removed and put in its proper place.

2. Guard. A point of danger like an exposed flywheel, driveshaft, exposed gears on a pumping unit or machine cannot be removed. The hazard should be covered or shielded by a substantial screen or enclosures.

3. Warn. If guarding is not practical, warn of the unsafe condition. Install danger signs or place a man there to serve as watchman in the danger area.

In many instances the supervisor needs help as the correction is out of his hands. What should be done?

4. Recommend. When the supervisor cannot remove or guard an unsafe condition, he should notify the proper authority about it. He should inform his own superior, other supervisors concerned, the safety department or maintenance engineer. When presenting report, make specific recommendations as to how the unsafe conditions can be eliminated.

5. Be sure to follow-up. The follow-up step, often neglected is the step that will get action. After a reasonable period of time, investigate to determine whether or not the unsafe condition has been corrected. If it has not, check with the person or persons to whom the recommendations were made.

When An Accident Occurs. In spite of every precaution you take, the time will come when an accident does occur. In a case like this rapid action is sometimes vital, therefore, there should be no time lost in wondering what to do, or how to do it. An alert supervisor will see that the following information is posted in as conspicuous a spot as possible in order to be readily available to everyone.

1. Whom to call when an accident or injury takes place.
2. Location of emergency equipment.
3. How to get in touch with the fire department, police, emergency crews of the local gas, electric, water, telephone and other utilities affected or concerned.
4. The telephone numbers of company doctors, hospitals and ambulance service available.

It goes without saying that the supervisor sees that all injuries, even minor cuts and bruises, receive immediate first-aid treatment.

Investigate Thoroughly. Once an accident occurs, and the immediate action necessitated by the emergency has been taken, it is the supervisor's responsibility to conduct an investigation to determine the cause so that a recurrence can be avoided.

Accident control measures are best served by thorough and factual investigations. The supervisor should realize the importance of such investigations and the promptness thereof. These reports are a record of experience and will point out which accident control efforts should be taken. Records are valuable as indicators or trends, and must reflect the true accident experience in order to serve their designed purpose.

Remember, unsafe acts and conditions can do nothing but lead to a high accident rate. The alert supervisor will always be looking for such conditions so he can eliminate them.

—The End

About the Author

J. A. Gavin, divisional safety supervisor, Tidewater Oil Co., Central division, Tulsa, has been with the oil industry for over 20 years, and with Tidewater over 12 years. His experience includes accident and fire control in refining, production, drilling, exploration, pipe line and marketing operations. He has specialized in casualty and compensation claims adjusting, and entered the accident prevention field after seeing the effects of accidents to working men and their families.

Pipe Stress Offshore

Continued from Page 54

left. The area of the moment diagram is considerably less than zero so with these forces, the pipe would be sloping downhill. Calculating (O — 1) as a circular arc (pipe level at O) R = 1,627.6 feet.

Using Equations 20 and 21 for the whole beam we get

$$M_a = O = M_{fa} - \frac{2EI}{L}\,O + O - \left(\frac{3y_b}{L}\right)$$

$$M_b = O = M_{fb} - \frac{2EI}{L}\,O + O - \left(\frac{3y_b}{L}\right)$$

Loading can be adjusted so these equations are true. The moments between supports then can be calculated to determine maximum values.

Experience During Construction. The stiffening effect of the concrete coating would tend to reduce stresses in the pipe, however, the amount of reduction was considered to be negligible. Factors which tend to make stresses worse include:

- Wave and current forces.
- Possible adhesion of silt or sea life to pipe.
- Tension or compression in pipe.
- Buoyant force is not continuous.
- Tolerances on pipe and coating.

Since they will balance out except in rough weather, these factors were ignored in the calculations.

After construction had started, it was discovered that loading conditions on the barge and difference in coating thickness produced a shorter radii than those calculated for the pipe. This was cracking the concrete coating and in some cases, exceeding the safe stress in the steel. At the end of 1957 construction, the radii of curvature were increased to the following:

26″ — 2,343′
20″ — 1,786′
16″ — 1,385′
12″ — 1,124′

Laboratory tests and field checks indicate that this analysis and derivation is satisfactory to predict stresses for any laying condition.

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WHAT'S HAPPENING

IN PIPE LINE CONSTRUCTION

By Donald G. DePugh, PIPE LINE INDUSTRY Staff

New Company Formed to Build Gas System in Texas

Capital Gas Pipe Line Company has been formed to construct a 370-mile gas gathering system in Central Texas to deliver gas to Austin.

Contracts for the system have been awarded to N. A. Saigh Co., Inc. Construction is scheduled to begin early this month.

The system will take gas from 120 wells in Hamilton, Eastland, Erath, Stephens, Palo Pinto, Parker, Coleman, Brown and Comanche counties and will provide gas to Austin for electric-power generation.

The $9 million project will consist of 120 miles of 12¾- and 14-inch main line, and 250 miles of 2- to 10-inch gathering lines. Although capacity of the system will be 135 MMcf daily, Capital is scheduled to supply only 35 to 40 MMcf to Austin starting in January.

Capital will purchase its gas from Mid-Tex Gas Company, an affiliated company.

Officers of the two companies are the same. John G. Pundt is president. R. Jacques T. du Pont, B. J. Wynne, James P. Roszel and E. D. Thomas are vice presidents, and Curtis B. Dall is secretary-treasurer.

United Gas Awards O. R. Burden Contract

United Gas Pipe Line Company has let contract to O. R. Burden Construction Corporation for construction of a 30-mile, 30-inch gas loop line across Lake Pontchartrain, La.

The lake crossing is part of United Gas' 203-mile, 30-inch project to loop its line between New Orleans and Mobile, Ala.

Contracts will be let soon on the remaining portion of the $33.7 million program. The first phase of the loop line will extend 78 miles from New Orleans to Hancock County, Miss., 38 miles from Hancock to Harrison County, Miss. The second phase of the line includes 86 miles along the southeast Louisiana-Mobile line.

Pipe Line Technology School

Pipe line participants in the fifth bi-annual pipe line technology school are shown just after opening classroom ceremonies at Lee College in Baytown, Texas. The school, which runs from September 15-October 24, is operated by The University of Texas Petroleum Extension Service under sponsorship of API's Committee on Personnel Training, Division of Transportation. Curriculum is composed of lectures, discussions, panels and field trips prepared particularly for the course by pipe line specialists. Several attending the school are from foreign countries. Top coordinators seated in the front row include Ken Cooley, Shell Pipe Line; Russell Brannon, Humble Pipe Line; Morgan Martin, Gulf Refining; Jim Conway, Petroleum Extension Service, and Dean James R. D. Eddy, The University of Texas Division of Extension.

Coastal Transmission Company Awards Contract For Main Line Construction

Coastal Transmission Corporation has awarded a contract to Oklahoma Contracting Company to build approximately 127 miles of 24-inch and 150 miles of 26-inch main lines as a part of the Texas to Florida gas line.

Burden will lay 127 miles in Louisiana and 150 miles in Texas with work starting this month. Coastal and Houston Texas Gas & Oil Corporation are building the 1,500-mile line which extends from McAllen, Texas, to Miami, Fla. Coastal will construct 574 miles from McAllen to Baton Rouge and Houston Texas Oil & Gas is building the 926-mile section to Miami.

In addition to its main line, Coastal will lay 414 miles of laterals and install four compressor stations. Contracts have been awarded for construction of the stations and part of the laterals. Gasoline Plant Construction Corporation will build stations at Robstown, Texas, 2,000 hp.; Bay City, Texas, 4,000 hp; Beaumont, Texas, 6,000 hp., and Baton Rouge, La., 8,000 hp.

Altgelt Construction Company, Inc. has started work on an 8-mile section of a 6-inch gathering line from East Corpus Christi Bay field in southwest Texas. A four-mile section of 8-inch pipe in Hidalgo County was completed last year.

Houston Texas Gas & Oil last year awarded contracts to Midwestern Constructors and Walco Engineering and Construction Company for construction of 700 miles of 24-inch main line from Baton Rouge to Kissimmee, Fla., and compressor stations in Santa Rosa, Liberty and Bradford counties, Fla., and George County, Miss. Harbert Construction Corporation will lay 240 miles from Kissimmee to Miami and 600 miles of laterals and distribution lines.

Construction Begins On 643 Miles Of Transco's 1958 Expansion Project

Construction got under way early last month on Transcontinental Gas Pipe Line Corporation's $167 million expansion project. Contracts have been let on a major portion of the proposal, and construction is expected to be completed by December to enable Transco to deliver additional gas to its northern markets before January.

Contracts have been awarded on 330 miles of 30- and 36-inch main line loops between Texas and New York, 150 miles of gathering and lateral lines in south Louisiana, and 193 miles of 24- and 30-inch Leidy laterals in Pennsylvania and New Jersey.

Bechtel Corporation received the largest main line loop portion with 134 miles of 36-inch in five states. Bechtel is laying 21 miles in Georgia, 21 miles in Alabama, 28 miles in South Carolina, 31 miles in Pennsylvania, 25 miles in New Jersey and 8 miles of 30-inch in Pennsylvania.

J. P. Neill has under way 27 miles, 36-inch, and 11 miles, 30-inch in North Carolina, and 36 miles of 36-inch in Virginia. Sharman, Allen, Gay & Taylor has contract for 122 miles of 36-inch in Texas, Louisiana and Mississippi.

The Leidy lateral section consists of 164 miles of 24-inch and 29 miles of 30-inch. Panama Williams is constructing 98 miles of 24-inch and 29 miles of 30-inch and Sharman, Allen Gay & Taylor is building the remaining 66 miles of 24-inch.

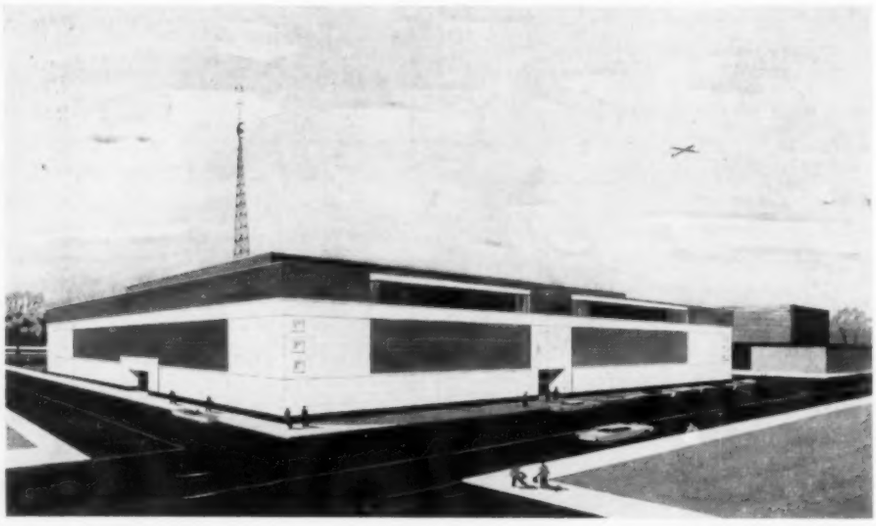
H. C. Price Construction Company is working on 65 miles of 24-inch gathering lines in south Louisiana and Sharman, Allen, Gay & Taylor is laying two 20-inch lines crossing the Mississippi River near Donaldsonville.

A part of Transco's 150 miles of offshore work will be laid by Brown & Root, Inc. this year. Brown & Root's contract calls for construction of 18 miles of 16-inch in Vermilion Block, and 24 miles, 16-inch, inland work at south Vermilion.

Hallmac Construction Company is building 20 miles, 12-inch, and 23 miles, 20-inch, laterals in South Louisiana.

Transco plans to let more contracts soon for its 1958 construction program. The entire project, calling for 556 miles of main line loops, over 500 miles of laterals and gathering lines, and 38,500 compressor horsepower including three new stations, will not be completed until 1959.

Completion of the 1958 facilities will increase Transco's delivery capacity to 1.2 billion cubic feet of gas daily.



Transco Plans Fourth Story Addition

Transcontinental Gas Pipe Line Corporation will begin work soon on a fourth story addition to its home office building in Houston. In contrast with the windowless three story structure, the front side of Transco's fourth floor will be glass. Cost of the 25,000 square-foot addition is estimated at $500,000. Manhattan Construction Company is the general contractor; Zimmerman and Bible are the architects and engineers.

Permian Plans 72-Mile Construction Project

Permian Basin Pipeline Company proposes to construct about 61 miles of 16-inch lateral supply lines, 11 miles of various diameter field lines, and nine meter stations to take natural gas from Emperor field, Winkler County, Texas.

Permian has filed an application with the Federal Power Commission for approval of the $3.7 million plan. Permian will purchase gas from Tidewater Oil Company, Sun Oil Company and Phillips Petroleum Company. The FPC has authorized Tidewater to sell to Permian. Sun and Phillips are awaiting FPC approval.

65-Mile Expansion Program Planned by Union Gas Co.

Union Gas Company of Canada Limited has announced plans for construction of 65 miles of main line extensions, and laterals.

The main line additions include a 45-mile, 8-inch segment between Stratford and Goderich, Ontario and 10 miles of 8-inch extending to Amhertburg. A 10-mile, 12-inch replacement line will be laid for a new feeder between Galt and Brantfort.

New York State Natural Receives FPC Approval

New York State Natural Gas Company has been given temporary authorization by Federal Power Commission for construction of a 30-mile, 12-inch gas line.

The line will extend from the company's present transmission line near Silver Springs to Iroquois Gas Corporation's Porterville compressor station near East Elma, New York.

Cost of the line and two metering stations is estimated at $1.6 million.

Manufacturers Project Authorized by FPC

The Federal Power Commission has authorized Manufacturers Light and Heat Company to construct 34 miles of 20-inch gas pipe line and a regulating station in Greene, Adams and York counties, Penn.

The additional facilities, estimated to cost $3 million, will be used to meet increased requirements of customers in New York and Pennsylvania.

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PROPOSED PIPE LINE CONSTRUCTION

Here in convenient summary form is Pipe Line Industry's listing of company, line size, length, service, location and project status.

U. S.

Capital Gas Pipe Line Company, Dallas, 370 miles, gas, gathering, take gas from Hamilton, Eastland, Erath, Stephens, Palo Pinto, Parker, Coleman, Brown and Comanche counties to deliver to Austin, Texas, $9 million, contracts let to N. A. Saigh Co., Inc.

Chicago District Pipeline Company, 52 miles, 30-36 inch, gas, from Natural Gas' proposed line at Joliet to Chicago, $13 million, before FPC.

Coastal States Gas Producing Co., Corpus Christi, Texas, 45-mile, gas gathering system in Bee County, Texas to connect with Texas Eastern's main pipe line, $1 million, planned.

289 miles, 14 and 18-inch main line and gathering system, McAllen to Falfurrias, Tex., area, and Lopena to La Salle County, $12 million, planned.

Coastal Transmission Corp., Houston, 574 miles, 22-24 inch, gas, from McAllen, Texas to Baton Rouge, La. connection of Houston, Texas Gas and Oil plus 414 miles of laterals, $55 million, contracts let on compressor stations to Gasoline Plant Construction Corp. Contract let on 275 miles to Oklahoma Contracting Company.

Colorado Interstate Gas Co., Colorado Springs, 140 miles, gas, main, Salt Lake City to Rock Springs, Wyo., planned.

Conn-Mass Pipe Line, Inc., Orange, Conn., 88 miles, 8 inch, products, from Boston to Springfield, Mass., considered.

133 miles, 16-inch, products, from Linden, N. J. to Hartford, Conn., considered.

62.2 miles, 8-inch, products, from New Haven, Conn. to Springfield, Mass., considered.

38 miles, 6-inch, products, from Waltham, Mass. to Fitchburg, Mass., considered.

Consumers Power Co., 45 miles, gas, main line, from Woodbury station to Laingsburg Junction, Mich., planned.

126-miles, 26-inch, gas, main, Michigan-Indiana border to Plymouth, Mich., planned.

Deep Rock Gas Co., Oklahoma City, 120 miles, 6-inch, LPG, from Tioga, N. D., to Canadian border, planned.

El Paso Natural Gas Company, El Paso, 216 miles, 26 to 34-inch main line, 533 miles, 6-20-inch laterals, gas, 86,750 compressor hp; 126 miles, 30-inch main line, 266 miles, laterals, gas, 28,920 compressor hp in new and existing stations in Arizona, New Mexico and Texas, contracts let on 819 miles to R. H. Fulton & Co., McVean & Barlow, Inc., Western Pipe Line, Inc., Eastern Pipeline Contractors, and Engineers Limited Pipeline Co.

400 miles, 34-inch, Salt Lake City, Utah, to California border, planned.

Emerald Pipe Line Corp., 195 miles, 6 inch, products, from Tucumcari, N. M., to Albuquerque, N. M., planned.

Equitable Gas Company, Pittsburgh, Penn., 11.7 miles of storage pipe line and other facilities, $2,091,430, authorized.

Everglades Pipe Line Company, Miami, Fla., 35 miles, 10-inch, products, Port Everglades to Miami International Airport, $2.5 million, planned.

Gillette Pipeline Co., Cheyenne, Wyo., 103 miles, crude, from Dead Horse Creek field to Casper, Wyo., planned.

Great Northern Railway, St. Paul, 400-600 miles, 12-20 inch, crude, from Williston Basin to St. Paul-Minneapolis and Duluth-Superior areas, considered.

Gulf Interstate Gas Co., Houston, 12.8 miles, 6 and 20 inch, gas, loop line in Louisiana, $730,000, authorized.

Gulf Pacific Pipe Line Company, 1,600 miles, 30-inch, gas, Louisiana to California border, considered.

Gulf Resources, New York, 125 miles, gas, gathering system, from Lopena area in Zapata County to a point in La Salle County, Texas, planned.

Harry Bass & Sons, Inc., Dallas, gas gathering lines, Pembina field, Alberta, $17 million, approved.

Humble Oil & Refining Co., 250 miles, 26 or 30 inch, gas and 116 miles, main gathering system, varying sizes, from southwest Texas to Houston, plus gas processing and cycling plant near Corpus Christi, $75 million, planned.

Interstate Oil Pipe Line Co., Shreveport, La., 35-miles, 6 and 8-inch, crude, Brookhaven to Gwinville, Miss., planned.

Iron Ranges Natural Gas Co., 115 miles, gas, from Itasca and St. Louis counties along route of Mesabi range from Grand Rapids to Aurora, Minn., $5 million, before FPC.

Jayhawk Pipeline Co., 140 miles, 6-inch, crude, from Meade County to Haskell and Morton counties, $2 million, considered.

Katy and New York Central Railroads, 2500-mile, 10-12 inch, LPG, from Houston, Texas, to New York, considered.

Kerr-McGee Oil Industries, Inc., 24 miles, 4 inch, gas, to connect wells with its Breton Sound production island off the Louisiana coast, authorized.

Magna Pipeline Co., 40 miles, gas, underwater line from Anacortes, Wash., to Victoria, B. C., $6 million, planned.

Manufacturers Light and Heat Co., Pittsburgh, Penn., 21-miles, gas facilities in Pennsylvania and West Virginia, $1 million authorized.

34-miles, 20-inch, in Greene, Adams, and York counties, Penn., authorized.

Michigan Gas Storage Co., Jackson, Mich., gas, facilities in central Michigan, $2 million, authorized.

Michigan Wisconsin Pipe Line Co., Detroit.

102 miles, 4- to 20-inch, gas lines to connect new gas supplies in Laverne field, Oklahoma, contracts let to Beadie Construction Co.

25.3 miles, 12-inch, lateral loop in Wisconsin, contract let to G. E. T. Construction Co.

20.5 miles, 24-inch, main line loop in Michigan, before FPC.

Midwestern Gas Transmission Co., Houston, 2067 miles, 3—24-inch, gas, from Emerson, Manitoba to Portland, Tenn., $111 million before FPC.

Mookl Chemical & Gas Corp., Tulsa, and **Missouri Transmission Corp.,** Springfield, Mo., 425 miles, 16-inch, gas, from Oklahoma City area to St. Louis, before FPC.

New York State Natural Gas Co., Pittsburgh, 30 miles, 20-inch, gas, main, Silver Springs to East Elma, N. Y., $1.6 million, temporary FPC authorization.

North Carolina Natural Gas Corp., 630 miles, 2-16 inch, from Transco's system near Mooresville across to southeastern North Carolina, $30 million contracts let on 200 miles to C. N. Flagg & Company.

Northern Illinois Gas Company, 140 miles, 24-inch, gas, main line, East Dubuque to Des Plaines, Ill., planned.

Northern Natural Gas Co., Omaha, 167 miles, 20 inch, gas, from Farmington, Minn. to Duluth, Minn., and Superior, Wis., $12 million, before FPC.

42 miles, 10 inch, gas, from Rochester, Minn. to Winona and Goodview, Minn., $963,000, before FPC.

365 miles, gas, new facilities in Minn., Iowa, S. D., Neb., Wis., plus 1090 miles of branch line and station facilities, $65.7 million, authorization for a part. Gas facilities in Texas, Oklahoma and Kansas, $6 million, before FPC.

454 miles, main line loops and extensions, 6-30-inch, main line from St. Cloud, Minn., to Grand Forks, N. Dak., also 1,490 miles of branch lines, 2-10-inch, and station additions totaling 32,000 horsepower, $86 million, planned.

27.6 miles, 30-inch, gas, loop; 18.3 miles north of Beaver station in Okla., 9.3 miles north of Sunray station in Texas, $3 million, authorized.

Northern Utilities Co., 35 miles, 16 inch, gas, in Fremont Natrona County, Wyo., area; 8 miles, 12 inch, around Casper; 6 miles, 8 inch, from Sand Draw gas field to Beaver Creek field; 12 miles, 6 inch, from Beaver Creek field to the system servicing the Riverton-Lander area, planned.

Ohio Fuel Gas Co., 51 miles, gas, main lines, in Belmont, Carroll, Cuyahoga, Fairfield, Logan, Lorain, Marion, Muskingun, Stark and Wayne counties, Ohio, $2.2 million, authorized.

Natural gas storage field in Medina

County, Ohio, 12 miles, 4½ to 20-inch, gas, $5 million, authorized.

Pacific **Gas & Electric Co.**, 1300 miles, 30-inch gas, from Alberta, Canada to Antioch, Calif., $380 million, planned.

Pacific **Lighting Gas Supply Co.**, 128-mile 34-inch, gas, main line from Topock, Ariz. to Newberry, Calif., planned.

Pacific **Northwest Pipeline Corp.**, Salt Lake City, 235 miles gas, gathering lines in San Juan Basin, Garmesa, Piceance Creek, and Big Piney Fields, $13.5 million, planned.

65 miles, gas, sales laterals in Washington, $1.5 million, planned.

Pennsylvania Gas Co., Warren, Penn., 38 miles, 8 and 10 inch, gas, in Erie and Warren Counties, Penn., and Chautauqua County, N. Y., $2.6 million, authorized.

Permian **Basin Pipeline Company**, Omaha, 61 miles, 16-inch, lateral, gas, 11 miles, various diameter, field lines, nine meter stations, to take gas from Emperor field, Winkler County, Texas, $3.7 million, before FPC.

Piedmont **Gas Co.**, Hickory, N. C., 78 miles, 2-8 inch, gas, from connection with Transcontinental Gas Pipe Line to serve customers in North Carolina, $2.6 million, authorized.

Pioneer **Natural Gas Co.**, Amarillo, Texas, 62 miles, 10-inch main, Pampa, Texas, to Canyon, in Randall County, Texas, 20 miles, small diameter, gathering, 4,000 h.p. stations, $4.5 million, planned.

Phillips Petroleum Co., 25 miles, 6 to 20-inch, gas, South Eunice, New Mexico area, planned.

52 miles, 4 to 20-inch, gas, Gaines County, Texas, planned.

44-mile, 6-inch, products line, from Rocky pump stations to Amarillo, Texas, planned.

Plantation Pipe Line Company, 48-mile, 4-inch, products, between Bremen and LaGrange, Ga., $1 million planned.

Service **Pipe Line Company**, Casper, Wyo., 4,000 compressor hp at Herndon, Kans., 2,000 compressor hp at Scranton, Kans., and 2,000 compressor hp at LaGrange, Wyo.; additional 2,000 hp at Laton station, Rocks County, Kans., 2,200 additional hp at Elk Basin, Kirby, Owl Creek, and Lost Cabin stations, north of Casper, Wyo., planned.

Shell Pipe Line Corp., Houston, 100 miles, 18-20 inch, crude, Southwest Pass to Norco Refinery near New Orleans, $10 million, contract let to Houston Contracting Co. on 62 miles.

3 miles, 8-inch, crude, main, and 20 miles, crude gathering, Colorado City, Texas, to Borden-Garza County of West Texas, planned.

Southern Kansas Pipe Line Co., Inc., Arkansas City, Kansas, 200 miles, 6-10 inch, crude, southwestern Kansas to Arkansas City, Kansas, planned.

Southern Natural Gas Company, Birmingham, 136 miles, 24 and 26 inch; 215 miles, various diameter supply lines; 3,150 additional compressor horsepower to White Castle and Toca Stations; 8 miles, 20-inch loops; 660 hp Franklinton station, and 23 measuring stations. $8.0 million, contracts let to William Brothers, Western Pipe Line, Inc, and River Construction Corp. on 183 miles.

458 miles, 16-24-inch, loop lines, gas, between Gwinville, Miss., and Wrens, Ga.; 62 miles, 14-inch, loops, along Atlanta-Macon line; 53 miles, 6⅝ to 14-inch, loops, along various branch lines. 3,140 additional hp at Gallion and Elmore, Ala. and Wrens, Ga. 60 miles, 20-inch, loops, in Louisiana between Franklinton and White Castle and South of Toca. Lateral lines south of Gwinville and west to Cranfield field. 8,720 hp added at Franklinton, White Castle, Patterson and Brookhaven. $65 million, contracts let to River Construction Corp., H. C. Price, and Houston Contracting Co. on 333 miles.

Tennessee Gas Transmission Co., Houston, 264 miles loop lines in Tennessee, Kentucky, West Virginia and Pennsylvania, FPC Examiner authorization.

Compressor stations in Mississippi, Tennessee, New York, Pennsylvania and additions in Tennessee, Kentucky, Ohio and Pennsylvania, $129 million, temporary FPC Examiner authorization.

21 miles, 16-inch, 2 miles, 12¾-inch, gas, Louisiana coast, Vermillion, Blocks 46 and 64, $2.9 million, before FPC.

Texas Eastern-Penn-Jersey Transmission Corp., Shreveport, La., 65 miles, gas, from Delmont, Penn., to Lambertville, N. J., before FPC.

24,000 compressor hp additions to existing stations, $4.4 million, temporary FPC authorization.

4,000 horsepower to its Delmont, Penn., compressor station, five new compressor stations in Pennsylvania with total capacity of 67,000 hp, $11.2 million, authorized.

Texas Eastern Transmission Corp., Shreveport, La., 267 miles, 14-30 inch, gas, Louisiana, Mississippi, Pennsylvania and New Jersey, $50 million, before FPC.

96.5 miles, 30-inch, gas, between Kosciusko, Miss., and Uniontown, Penn.; 9.4 miles of supply laterals; a 10,250 hp compressor station, and 33,360 hp to existing compressor stations, $24.5 million, authorized.

141,780 additional horsepower in existing stations, a new 2,200 hp compressor station, in Louisiana, Mississippi, Pennsylvania, Ohio, Kentucky and Tennessee, authorized.

Texas Eastern Transmission Corporation and Wilcox Trend Gathering System, Inc., gas, compressor stations, $4 million, authorized.

Texas Gas Gathering Corp., Shreveport, 36.6 miles, gas, gathering system in Rodney Field, Jefferson County, Miss. and from North and South Locust Ridge, Lake St. John Field in Tensas and Concordia parishes, La., $855,413, before FPC.

Texas Gas Transmission Corporation, Owensboro, Ky., 92 miles, 30-inch, 19 miles, 26-inch, and 15 miles, small diameter, loop portions of system in Louisiana, Arkansas, Mississippi, Kentucky, Indiana and Illinois; additional horsepower at Pineville, La., Kenton, Tenn., Calvert City, Ky., Slaughters, Ky., Dillsboro, Ind., and Petersburg, Ind., totaling 9,040 hp. $20 million, before FPC.

Texas Illinois Gas Pipeline Company, Chicago, 16,000 additional hp to stations at Lufkin, and Marshall, Texas; Texarkana, Malvern, Searcy, and Biggers, Ark.; Jackson, Mo.; and Hammond, Ill., $3.9 million, before FPC.

Transcontinental Gas Pipe Line Corp., Houston, 204 miles, 36-inch, 107 miles, 30-inch, main line loops in 10 states; 3 intermediate stations: North Carolina, Virginia, Pennsylvania; 2,500 additional hp at six compressor stations; 164 miles, 24-inch from Leidy storage Penn.; 29 miles, 30-inch, New Jersey; gathering lines, Louisiana, 119 miles; 10 meter stations; additions to West Cameron and High Island area, 35-miles, 16-inch, 26 miles, 10-inch, and three gathering meter stations; 45 miles, 16-inch, purchase laterals and 5 meter stations, Louisiana; 67 miles, 10, 12, 20-inch miscellaneous transmission purchase laterals in Texas and Louisiana, 3 meter stations; 51 miles, 36-inch and 1 mile, 30-inch in New Jersey; 51 miles, 10- and 14-inch and 3 meter stations, southeast Louisiana (mainly offshore), $137.3 million. Contracts let on 643 miles for Bechtel Corp., Sharman, Allen, Gay & Taylor, Panama Williams, J. P. Neill, H. C. Price, Brown & Root, and Hallmac Construction Co.

151 miles, 24-inch, 12 meter stations, southeast Louisiana, $14.5, authorized.

2,500 additional hp at four compressor stations, St. Francisville, La.; Laurel, Miss.; Linden, Ala. and Wadley, Ala., $3 million, authorized.

Wells, pipe lines, measuring equipment, stations at Leidy storage in Pennsylvania, $12.5 million, authorized.

Trans-Utah Pipeline, 120 miles, 16-inch, gas main line from Uinta Basin to Salt Lake City, considered.

Transwestern Pipeline Company, Houston, 1,305 miles, 24- and 30-inch, gas, main line, from West Texas and Oklahoma-Texas Panhandle area to Topock, Ariz., $193 million, before FPC.

Trunkline Gas Company, Houston, 204 miles, 26-inch, gas, main line from Tuscola, Ill., to Michigan-Indiana border; 464 miles, 30-inch loops between Longville, La., and Tuscola and 45 miles, 24-inch, in Texas, 183 miles gathering, Louisiana, 3000 additional hp at Longville station, $81.5 million, before FPC.

Underground Storage & Exploration, Upper Darby, Penn., 394 miles, 12-inch LPG, from Moundsville, W. Va. to Newark, N. J., $9 million, approved.

95 miles, 6-8 inch, laterals to Mauch Chunk, Penn., and to Philadelphia, planned.

United Gas Pipe Line Co., Shreveport, La., 203 miles, 30-inch, gas, between New Orleans and Mobile, Ala., $33.7 million, contracts let on 30-miles to O. R. Burden.

International

ACT Oils, Ltd., Montreal, 400 miles, crude, Dawson Creek, B. C., to Bella Coola, B. C., before B. C. government.

Alaska-Yukon Refiners and Distributors, Ltd., Edmonton, Alta., 150 miles, products, serving Alaska and Yukon territory, $3.5 million, planned.

Bituminous Oil Pipeline Co., Calgary, 250 miles, crude, from Athabasca tar sand plant in northeastern Alberta to Ed-

monton, approved.

British Petroleum Co., 60 miles, crude, from deep water tanker terminal at Milford Haven, U. K. to Llandarcy Refinery, $18 million, planned.

Burmah Oil Co., Ltd., 850 miles, crude, 20 inch, from Nahorkatiya to Calcutta, India, planned.

Consolidated Gathering Systems, Ltd., Calgary, 198 miles, crude, Sturgeon field to Edmonton, planned.

Development and Resources Corp., 70 miles, 8 inch, gas, from Agha Jari oil field to Ahwaz, Iran, planned.

Elburz Oil Corp., 1000 miles, crude, from Central Iran to Alexandretta, Turkey, $450 million, planned.

Entre Nazionali Idrocarburi, Rome, Italy, crude, from Qum field in Iran to the Mediterranean Sea, considered.

Foothills Pipe Line, Ltd., 500 miles, 12 to 16-inch, LPG, from Alberta to Pacific Coast, $80 million, considered.

Hydrocarbons Pipeline, Ltd., Winnipeg, Manitoba, 880 miles, 6-8 inch, products, from Edmonton to Winnipeg, $35 million, partial authorization.

Independent Pipe Line Co., 2,019 miles, 34-36-inch, crude, Edmonton to Montreal, 23,000 pump horsepower, $395 million, before Borden Commission.

Interprovincial Pipe Line Company, 350-mile extension from Toronto to Montreal, looping line from Edmonton to Toronto, crude, $240 million, considered.

Mid-Continent Pipe Lines, Ltd., 1500-mile, 30-inch crude, Edmonton to Chicago, planned.

National Iranian Oil Co., 146 miles, 6 inch, crude, from Azna to Isfahan, Iran, $5 million, planned.

1000 miles, 38 inch, crude, from central Iran to the Turkish Mediterranean coast, considered.

Peace River Oil Pipe Line Co., Ltd., 70-mile, crude, Swan Hills to Iosegun Junction, approved.

Petroleos Mexicanos, 108 miles, 10 inch, gas, from Gral. Escobedo to Monclova to tie into Reynosa-Monterrey gas pipe line, $9 million, planned.

600 miles, 24 inch, gas, from Pemex City to Mexico City, $50 million, planned.

38 miles, 4 inch, products, from Mexico City to Toluca, $500,000 planned.

126 miles, 4, 6 and 8 inch, products, from Mexico City to Cuernavaca and Puebla, $2.5 million, planned.

Sui Gas Transmission Co., Multan, Punjab, India, 145 miles, 8-inch, gas, from Sylhet to Dacca, East Pakistan, $9 million, considered.

130 miles, 16-inch, gas, main line, Multan to Lyallpur, planned.

Trans-Europe Pipe Line, 700 miles, 30 inch, main trunk, crude, from Mediterranean to northern Europe, considered.

Union Gas Company of Canada Limited, 45 miles, 8-inch, gas, main, Stratford to Goderich, Ontario; 10-miles, 8-inch, main, to Amhertburg; 10-miles, 12-inch, lateral, Galt to Brantford, planned.

Westcoast Transmission Company, Ltd., 174 miles, 30-inch, gas, Savanna Creek gas field, Alberta, to British Columbian border, $45 million, planned.

650 miles, crude, from Peace River area to Vancouver, $100 million, planned.

Williams-McWilliams Industries, Inc., New York, 441 miles, 6-inch, crude, Villa Montes, Bolivia to Villa Hayes, Paraguay, considered.

Yacimientos Petroliferos Fiscales, Buenos Aires, Argentina, 621 miles, 12-inch, products, Mendoza to San Lorenzo, Argentina, $19 million, planned.

281 miles, 12¾ inch, crude, Pichanal to San Miguel Tucuman to Techint, S. A., planned.

450 miles, 16-inch, crude, from Neuquen Province to Bahia Blanca, planned.

Interstate Oil Pipe Line Plans 35-Mile Extension

Interstate Oil Pipe Line Company plans to construct a 35-mile extension of its main line extending from Brookhaven, Miss., to its crude system near Gwinville, Miss.

The extension will provide pipe line transportation for the recently discovered Raleigh, Martinville and Magee fields in Simpson and Smith counties, Miss.

Presently oil is delivered by truck to Interstate's system at Gwinville. Irish Engineering Service has been awarded contract for reconditioning the 6- and 8-inch pipe for the job. Contract for construction will be awarded soon, and the project will be completed by January.

Westcoast Expands Gas Gathering System

Westcoast Transmission Company has completed its 84 miles of gathering lines extensions northwest of Fort St. John, B. C.

The $7 million project brings the total length of Westcoast's gathering facilities to 240 miles and will tie in 21 more gas wells to the company's grid which terminates at Taylor. The new lines will provide 80 MMcf of gas daily to the McMahon plant at Taylor.

Ultimate capacity of the extension will be 150 MMcf daily.

Interprovincial Pipe Line Completes Looping Project

Interprovincial Pipe Line Company has completed an 82-mile looping project on its 1,913-mile crude line extending from Edmonton, Alberta, to Port Credit, Ontario.

The additional looping project ended a six-year construction program by which Interprovincial doubled its line between Edmonton and Superior, Wis. The 82 miles of 24-inch were laid between pumping stations at Loreburn and Kerrobert, Saskatchewan, and Hardisty and Edmonton.

Service Completes Pipe Line Expansion

Service Pipe Line Company has completed its pipe laying expansion program in Wyoming. O. R. Burden has constructed 123 miles of 12- and 20-inch loops from a point north of Salt Creek station to Fort Laramie.

Construction consisted of 30 miles, 12-inch, from Salt Creek station; 17 miles, 12-inch from Casper station toward Salt Creek; 76 miles, 20-inch between Casper and Fort Laramie.

Pasotex Buys Lines From Gulf Refining

Pasotex Pipe Line Company has purchased two crude oil gathering systems in Scurry County, Texas from Gulf Refining Company.

The two systems, which handle about 5,000 b/d, serve the SACROC unit in Kelly-Snyder field and the Sharon Ridge Canyon unit in Sharon Ridge Canyon field.

Pasotex, a subsidiary of Standard Oil Company of Texas, will use the systems to supply crude to its main line which runs from the Kelly-Snyder area to Wink.

Cities Service Files Application With FPC

Cities Service Gas Company has filed an application with the Federal Power Commission seeking permission to construct two 1,350 horsepower compressor units.

One unit would be an addition to Cities Service's existing Ulysses compressor station in Grant County, Kansas; the other would be constructed as a new station in Haskell County, Kansas. Cost of the facilities would be $787,000.

Southern Natural Awards Contract to Latex Firm

Southern Natural Gas Company has awarded a contract to Latex Construction Company for construction of 22 miles of 14-inch gas main line in Georgia. This is part of Southern's expansion program to loop its system in Louisiana, Mississippi, Alabama and Georgia.

A Pipeliner's Checklist

Just What Do These Corrosion Terms Mean?

Here's a helpful list of standard corrosion definitions for the pipe line engineer

The **Inter Society Corrosion Committee's** subcommittee on Standard Definitions and Terminology has compiled and recommended as standards for use in corrosion control communications a list of 103 corrosion definitions. This Corrosion Committee is composed of 32 representatives from technical societies and organizations interested in improving the exchange of corrosion information between all who are interested in the problem. In addition to information exchanged between United States scientific and engineering groups, reports from correspondents in France, Germany, Italy, Japan, New Zealand, Spain and Switzerland were included.

Here is a glossary of terms of interest to pipeliners, abstracted from the complete list.

Active—A state wherein passivity is not evident.

Anaerobic—Free of uncombined oxygen.

Anion—A negatively charged ion or radical which migrates toward the anode under the influence of a potential gradient.

Anode—An electrode or portion of an electrode at which a net oxidation reaction occurs.

Anode Corrosion Efficiency—The ratio of the actual corrosion of an anode to the theoretical corrosion calculated from the quantity of electricity which has passed.

Anodic Polarization—Polarization of anodes.

Anti-Fouling—Pertaining to the prevention of marine organism attachment and growth on a submerged metal surface [through the effects of chemical action].*

Austenitic—The face-centered cubic crystal structure of ferrous metals.

Cathode—An electrode or portion of an electrode at which a net reduction reaction occurs.

Cathodic Corrosion—An increase in corrosion of a metal by making it cathodic.

Cathodic Polarization—Polarization of cathodes.

Cathodic Protection—Reduction or prevention of corrosion by making a metal the cathode in a conducting medium by means of a direct electric current [which is either impressed or galvanic].*

Cation—A positively charged ion or radical which migrates toward the cathode under the influence of a potential gradient.

Caustic Embrittlement—Stress-corrosion cracking in alkaline solutions.

Cavitation Damage—Deterioration caused by formation and collapse of cavities of liquid.

Chalking—The development of loose removable powder at or just beneath a coating surface.

Concentration Cell—An electrolyte cell, the emf of which is due to differences in composition of the electrolyte at anode and cathode areas.

Concentration Polarization—That portion of the polarization of an electrode produced by concentration changes at the metal-environment interface.

Corrosion—The deterioration of a substance [usually a metal]* because of a reaction with its environment.

Corrosion Fatigue—Reduction in fatigue life in a corrosive environment.

Corrosion Fatigue Limit—The maximum repeated stress endured by a metal without failure in a stated number of stress applications under defined conditions of corrosion and stressing.

Corrosion Rate—The rate at which corrosion proceeds.

Crevice Corrosion—Localized corrosion as a result of the formation of a crevice between a metal and a nonmetal, or between two metal surfaces.

Current Density—The current per unit area.

Deactivation—The process of removing active constituents from a corroding liquid [as removal of oxygen from water].*

Demineralization—The process of removing dissolved minerals [usually by chemical means].*

Depolarization—Reduction or elimination of polarization by physical means or change in environment.

Deposit Attack (Deposition Corrosion)—Pitting corrosion resulting from deposits on a metallic surface.

Drainage—Conduction of current (positive electricity) from an underground metallic structure by means of a metallic conductor.

Electrochemical Equivalent—The weight of an element or group of elements oxidized or reduced at 100 percent efficiency by a unit quantity of electricity.

Electrolysis—Chemical change in an electrolyte resulting from an impressed current.

Electrolyte—An ionic conductor.

Electrolytic Cleaning—The process of degreasing or descaling a metal by making it an electrode in a suitable bath.

Electromotive Force Series—A list of elements ar-

ranged according to their standard electrode potentials.

Embrittlement—Severe loss of ductility of a metal or alloy.

Endurance Limit—The maximum stress a metal can withstand without failure during a specified large number (usually 10 million) cycles of stress.

Equilibrium Potential—The electrode potential at equilibrium.

Erosion—Deterioration by the abrasive action of fluids, usually accelerated by the presence of solid particles of matter in suspension. When deterioration is further increased by corrosion, the term erosion-corrosion is often used.

Fatigue—The tendency for a metal to fracture in a brittle manner under conditions of repeated cyclic stressing at stress levels below its tensile strength.

Fouling—The accumulation and growth of marine organisms on a submerged metal surface.

Galvanic Cell—A cell in which chemical change is the source of electric energy. [It usually consists of two dissimilar conductors in contact with each other and with an electrolyte, or two similar conductors in contact with each other and with dissimilar electrolytes.]*

Galvanic Series—A list of metals and alloys arranged according to their relative potentials in a given environment.

Hydrogen Embrittlement—Embrittlement caused by hydrogen.

Hydrogen Overvoltage—Overvoltage associated with the liberation of hydrogen gas.

Impingement Attack—Localized erosion-corrosion resulting from turbulent or impinging flow of liquids.

Inhibitor—A substance which retards corrosion when added to an environment in small concentrations.

Intergranular Corrosion—Corrosive attack which progresses preferentially at grain boundaries.

Ion—An electrically charged atom or radical.

Local Action—Corrosion due to the action of "local cells," i.e., galvanic cells resulting from inhomogeneities between adjacent areas on a metal surface exposed to an electrolyte.

Local Cell—A galvanic cell resulting from inhomogeneities between areas on a metal surface in any electrolyte. The inhomogeneities may be of physical or chemical nature in either the metal or its environment.

Long-Line Current—Current (positive electricity) flowing through the earth from an anodic to a cathodic area which returns along an underground metallic structure. Usually used only where the areas are separated by considerable distance and where the current results from concentration cell action.

Mill Scale—The heavy oxide layer formed during hot fabrication of heat treatment of metals. [Especially applied to iron and steel.]*

Open Circuit Potential—The measured potential of a cell from which no current flows in the external circuit.

Overvoltage—The displacement of an electrode potential from its equilibrium (reversible) value because of flow of current.

Oxidation—Loss of electrons by a constituent of a chemical reaction.

Oxygen Concentration Cell—A galvanic cell resulting primarily from differences in oxygen concentration.

Passivation—The process or processes (physical or chemical) by means of which a metal becomes passive.

Passivator—An inhibitor which changes the potential of a metal appreciably to a more cathodic or noble value.

Pickle—A solution or process used to loosen or remove corrosion products such as scale and tarnish from a metal.

Pitting—Localized corrosion taking the form of cavities at the surface.

Pitting Factor—The depth of the deepest pit resulting from corrosion divided by the average penetration as calculated from weight loss.

Polarization—The displacement of electrode potential resulting from the effects of current flow, measured with respect to either equilibrium (reversible) or steady state potentials.

Reduction—Gain of electrons by a constituent of a chemical reaction.

Rust—Corrosion product consisting primarily of hydrated iron oxide. [A term properly applied only to iron and ferrous alloys.]*

Sacrificial Protection—Reduction or prevention of corrosion of a metal in an environment acting as an electrolyte by coupling it to another metal which is electrochemically more active in that particular electrolyte.

Scaling—1. The formation at high temperature of thick corrosion product layer(s) on a metal surface.

2. The deposition of water-insoluble constituents on a metal surface (as on the interior of water boilers).

Spalling—Spontaneous separation of a surface layer from a metal.

Stray Current Corrosion—Corrosion caused by current through paths other than the intended circuit or by an extraneous current in the earth.

Stress Corrosion Cracking—Spontaneous cracking produced by the combined action of corrosion and static stress (residual or applied).

Subsurface Corrosion—Formation of isolated particles of corrosion product(s) beneath the metal surface. This results from the preferential reaction of certain alloy constituents by inward diffusion of oxygen, nitrogen, sulfur etc. (Internal oxidation).

Tarnish—Surface discoloration of a metal caused by formation of a thin film of corrosion product.

Tuberculation—The formation of localized corrosion products scattered over the surface in the form of knoblike mounds.

Underfilm Corrosion—Corrosion which occurs under films in the form of randomly distributed hairlines (filiform corrosion).

Weld Decay—Localized corrosion at or adjacent to a weld.

* Portions shown within brackets [ ] are not required for the definition and may be deleted. They have been added to make the definition more easily understood.

ACKNOWLEDGMENT

This glossary of corrosion terms was abstracted from complete lists published in the February and July, 1958 issues of "Corrosion" magazine which covers many other subjects in addition to pipe line engineering terms.

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Pipe Line Construction —19—How to Find Cut Back On 90° Weld Ell

When it is necessary to construct a weld ell of any desired radius from a 90-degree weld ell, use of ratio and proportions will give the measurement for both the outside and inside cut back.

Example: Find cut back on a 90-degree weld ell to provide a 58-degree ell.

Outside measurement—75 inches

Inside measurement—37 inches

Outside cut back

$$\frac{75}{90} = \frac{\times}{58} = 48\frac{5}{16} \text{ inches}$$

Inside cut back

$$\frac{37}{90} = \frac{\times}{58} = 23\frac{13}{16} \text{ inches}$$

Miscellaneous —36—Protect Fire Equipment from Freezing

With cold weather coming, antifreeze must be added to buckets, pails, barrels and hand fire extinguishers at unheated locations. An economical method is to add calcium chloride to the water.

Since the calcium chloride solution is corrosive, it should be used only in equipment which has a protective coating. Quantities of calcium chloride required for various temperatures are given in the table below. This table is based on 17 percent calcium chloride (granulated). Quantities given are for 2½ gallons of solution.

Temperature	Amount Calcium Chloride
10° F.	5 pounds
Zero	6¼ pounds
— 10° F.	7⅜ pounds
— 20° F.	8⅜ pounds
— 30° F.	9⅛ pounds
— 40° F.	10 pounds

R. John Lind
434 South 2nd St.
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Corrosion Protection —18—Insulating Flanges Reduce Cathodic Protection Needs

A savings in cathodic protection costs on spot-coated pipe lines can be realized by installing insulating flanges at each end of a coated section during construction if the length of the coated section is as great or greater than the distance shown in the following table for various line sizes.

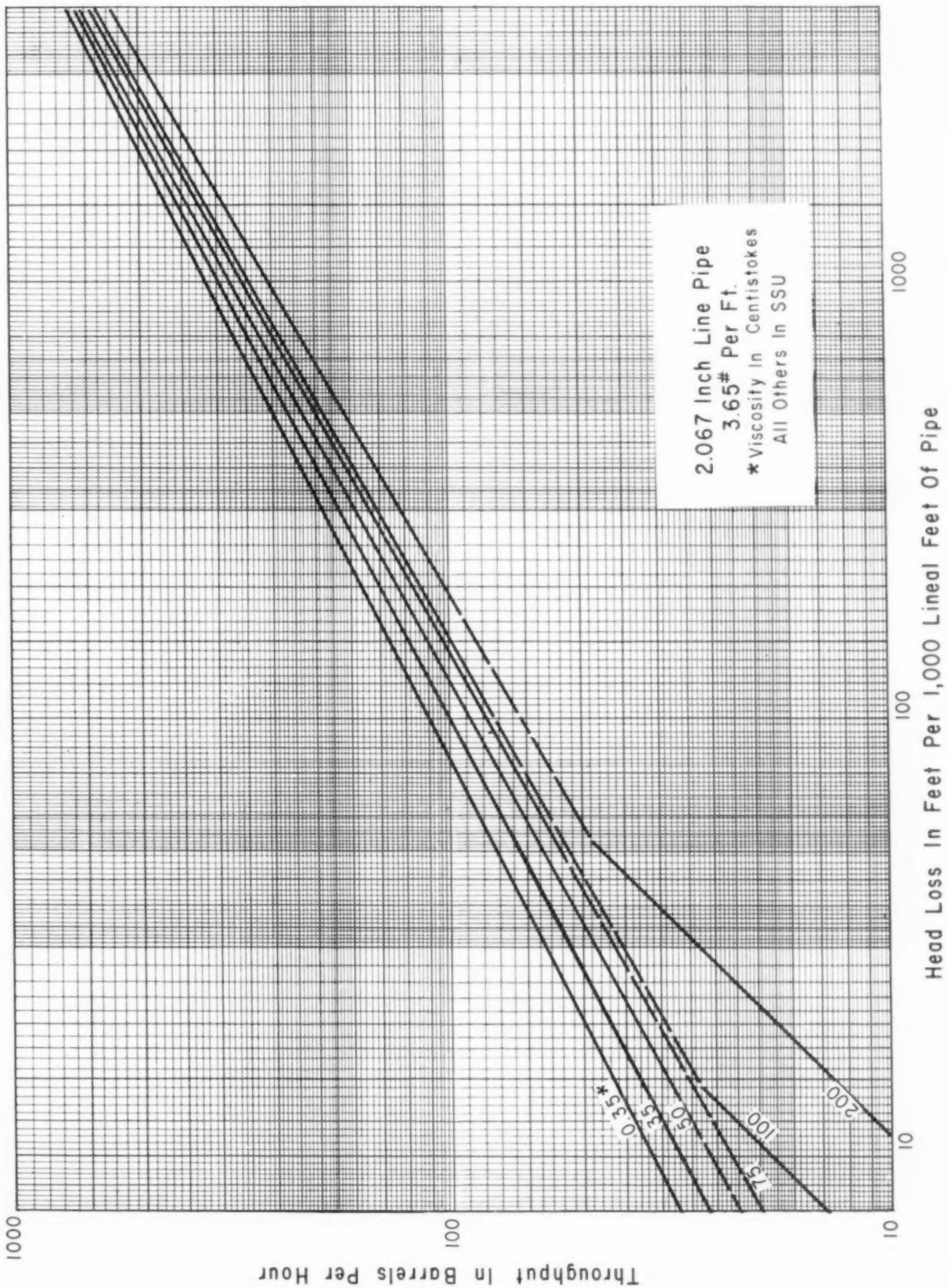
	Minimum Length of Section	
Line Size	150-Pound Insulating Flanges	300-Pound Insulating Flanges
2-inch	200 feet	300 feet
3-inch	300 feet	400 feet
4-inch	400 feet	500 feet
6-inch	500 feet	700 feet
8-inch	600 feet	900 feet
10-inch	800 feet	1,200 feet
12-inch	1,100 feet	1,700 feet
14-inch	1,100 feet	1,800 feet
16-inch	1,200 feet	2,100 feet
18-inch	1,600 feet	2,800 feet
20-inch	1,900 feet	3,300 feet
24-inch	2,700 feet	5,100 feet

Engineering Design —55—Head Loss Charts for Various Sizes of Pipe

Friction Loss Characteristics for 2-inch pipe were computed by a pipe line company using data of the Hydraulic Institute. Use of these data in laminar and critical zones is adequate for estimates. Friction losses in transition and complete turbulent zones are very accurate.

(Chart 15 in a series of 19—2-inch line pipe)

ENGINEERING DESIGN 55



How to do it

PIPE LINE HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, PIPE LINE INDUSTRY, P. O. Box 2608, Houston 1, Texas

Channel Supports Serve As Brace For Heavy Valves

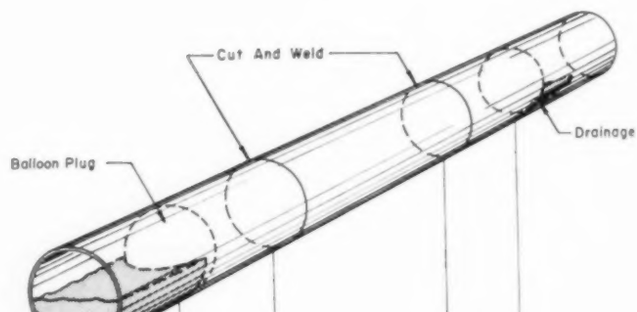
Simple 3-inch channel supports can be used to support heavy high pressure valves, filters, strainers etc. that are installed above grade on small diameter lines. These supports eliminate possible weld failures due to this excessive weight, and also prevent settling due to loose backfill after construction.

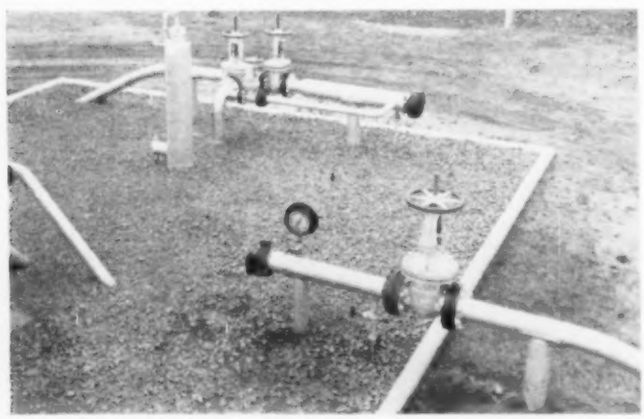
This arrangement minimizes maintenance and lends itself to operating ease. To eliminate vibrations from being transferred into these small lines, a stainless steel flexible hose can be installed as shown. This hose is available in high pressure ratings, sizes, and lengths and is readily installed in the piping run. These vibrations often cause weld failures in these small diameter lines.

Surplus Balloons Seal Pipe Line For Repairs

Army surplus weather balloons can be used to replace the "mud plug" while repairing a pipe line. Two inflated balloons are inserted a distance of 30 to 36 inches on either side of the pipe section to be isolated. The balloons will hold back any oil or salt water which might drain toward the open section of the line. After the repairs are complete, a low pressure head will force the balloons downstream. After travelling a short distance the balloons will probably break due to slag, welds, friction or other projections in the line and will end up in the bottom of a strainer.

Diameter of the balloons is not critical, but they should be from 2 to 4 inches larger in diameter than the pipe. Plastic weather balloons that can be purchased in most Army-Navy surplus stores are very satisfactory for this purpose.





Arrange Pig Traps to Keep Gathering System Clean

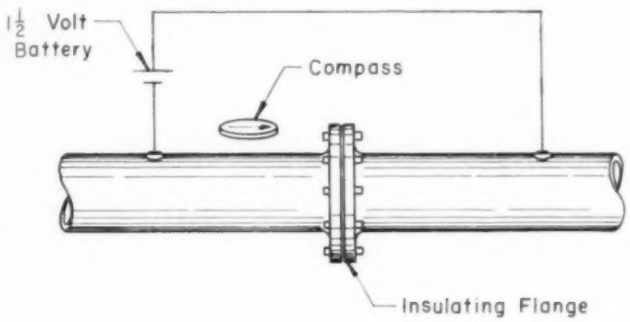
Where heavy paraffin crudes are being pumped, a simple arrangement for handling the pipe cleaning pigs is to place the inlet and outlet connections at a convenient place to the field pumping station. Every 30 days, the pigs are inserted at the tank battery and caught in the chamber in the background. When the pumping unit operator comes on duty, he removes the one-bolt union and takes out the pig and inserts it on the down stream side of the pump. This is a convenient method of keeping the gathering system free of paraffin deposits.

Mobile Power-Driven Buffers Speed Stringer Bead Welding

Line-up and stringer bead welding can be speeded up by use of mobile power driven buffers ahead of the line-up gang.

A contractor on a Pennsylvania job installed a portable light plant to furnish power for electric hand grinders ahead of the line-up gang.

For mobility the light plant can be mounted on the back of a jeep or other mobile equipment. Such a source of power is cheap and reliable and easy to operate, requiring little maintenance. With this arrangement one man can keep ahead of the line-up and welding crew and have the pipe bevel ready for welding.



Pocket Compass Indicates Shorted Insulating Flanges

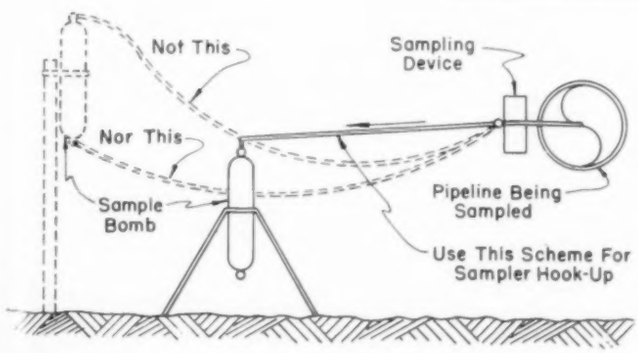
The use of a pocket compass in conjunction with a battery is a simple way to test insulating flanges. This test is made by placing the compass on the pipe near the flange with the battery connection on each side of the flange.

If there is a low resistance leak in the insulation, when the battery circuit is closed the flow of current will cause the compass needle to move. If the insulation is effective, the current must take the soil path and will not disturb the magnetic field of the compass, and the needle will remain in the proper position.

Pipe Trailer Loaded Easily Upside Down

When one pipe hauler found that the pipe trailer tended to lean over every time it was loaded and then seemed to always be upside down when unloaded, the driver tried loading it upside down; then when it was unloaded, it was sitting upright. This was accomplished by unhooking the trailer coupling and telescoping the tongue back into the trailer.

The winch line then was thrown over the top of the trailer and the load "rolled" up onto the back of the truck bed. When the truck was returned to the pipe yard for another load, the winch line was run through a sheave on the ground and the trailer pulled back off. As soon as the wheels were off the back of the trailer, they naturally swung down and were on the ground ready for the tongue to be extended and fastened to the back of the truck.



Proper Sampler Hook-up Eliminates Sags in Line

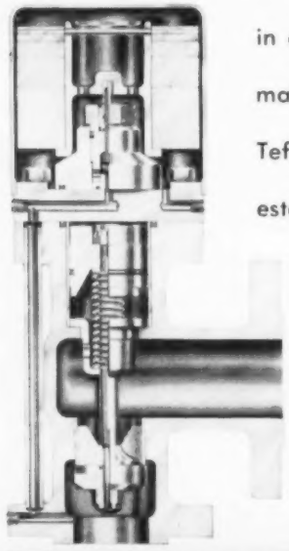
Pipe line installations using automatic samplers should be free of sags in the lines from sample tap to the container. Sags, as shown in the illustration, form natural traps for BS&W, giving erroneous samples and actually cost the firms considerable money where LACT or other custody transfer is involved. Also, the sample catcher should always be below the sampled line outlet. The proper sampler hook-up is shown in the sketch.

The New Model 412 Kinzbach Pressure Relief Valve

The new, improved Kinzbach Model 412 relief valve for pipelines and refineries, has a ball seated pilot valve, usually dead weight loaded, but optionally spring loaded.

Eleven advantages are included in the design and operation of this new model:

1. Positive action—line pressure is utilized for opening and closing.
2. Dependable. Opening pressure is pre-set by application of dead weight or spring load.
3. Instantaneous opening to full capacity.
4. Automatic reseating.
5. No chatter or wire-drawing at seat.
6. Functional Testing. Hand lifting of pilot stem operates valve at **any** pressure.
7. Simple and rugged. Valve contains only two moving assemblies.



8. High capacity. Ample flow area provided in all sizes.
9. Positive Seating. Line pressure utilized to maintain valve shut.
10. Corrosion resistant. Full stainless trim with Teflon disk.
11. No pressure accumulation needed. Full lift established immediately.

Model 412 Valve sizes are 2", 3", 4", 6" and 8" with working pressures up to 1000 p.s.i.; pilots are available in four ratios: 5:1, 10:1, 25:1, and 50:1. For complete details on this and other Kinzbach pressure relief valves, write for new catalog.

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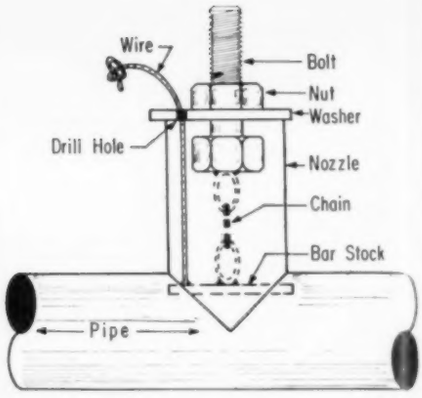
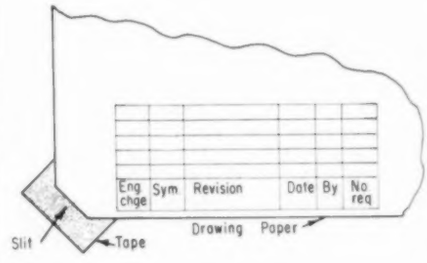


One Man Can Position Nozzle Firmly for Welding

A welder without a helper has his hands full in trying to fasten a nozzle to a pipe before welding. One way to simplify the procedure is to weld a short length of chain to a bolt head and a piece of bar stock, as shown in the drawing. By tightening down on the nut, the nozzle can be positioned for welding.

A wire is tacked to the bar stock and is pulled through a hole drilled in the washer. To remove, simply loosen the nut, drop the assembly into the pipe and pull on the wire (in order to straighten the bar stock for removal).

One man can position the nozzle quickly and accurately in any position, and have a steady piece of work to weld.

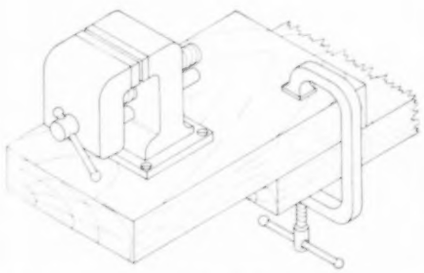


Split Masking Tape To Secure Drawings

Masking tape is widely used to hold drawings to the board. However, it sometimes poses a problem for the draftsman. Each time the straight edge passes over the tape, it tends to pull the tape loose. Simply by splitting the tape, as shown, this trouble can be eliminated. The straight edge passes over the drawing corner without interference from the edge of the tape.

Dog Leash Makes Handy Ground for Truck Loading

Where trucks are to be grounded at the truck loading terminal, a handy way to keep the ground wire out of the way when the trucks are not in, is to use a dog leash with a retractable reel so that the wire winds itself up when not in use. First the reel is taken apart so that it makes a good connection, whether it is extended or retracted, then it is fastened solidly at a convenient place for the loader. A metal clip is installed on the end, and when the trucks come in, it is a simple matter to unwind the reel and attach the ground cable before the filler caps are removed. When the truck has been filled, the cable is unsnapped and retracts itself instantly.



Make Portable Vise by Mounting on Block of Wood

A convenient, portable vise can be made by mounting a small bench vise on a piece of two-by-four or two-by-six. The vise can then be taken anywhere for use and mounted rigidly and securely by the use of a C-clamp.

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What's Happening among MEN in the INDUSTRY

J. L. Gere

R. W. Hofsess

Three promotions are announced by Cities Service Gas Company. **Clint D. Rogers**, formerly manager of transmission, has been named vice president in charge of the Transmission department. **Russell W. Hofsess**, former manager of production and supply, has been appointed vice president in charge of Production and Supply division. **John L. Gere**, chief engineer, has been named to head the Engineering and Research division.

C. D. Rogers

Rogers has been with the company since 1927. He served in various positions including assistant superintendent of pipe line department, 1936. He became manager of transmission 1953. Hofsess joined Cities Service in 1933. Since then he has been pipe line foreman at Petrolia, Kansas, and superintendent of company's Pipe Line department. He was made manager of production and supply in 1953. Gere, who has been with the company since 1927, was division pipe line superintendent at Blackwell and Drumright in 1932. He was promoted to chief engineer in 1953 and was elected a director of the company in 1956.

Charles W. Guy has joined the **General Gas Corporation** Baton Rouge firm as executive vice president and a member of the board of directors.

Guy held the position of executive vice president and director of General Gas prior to his resignation in 1954. Since that time he has served as vice president and treasurer of Texas Natural Gasoline Corporation. Guy began his career with General Gas in 1939 as an auditor and was appointed vice president in 1942. He was elected executive vice president in 1949. Guy also served as a member of the board of directors of the Liquefied Petroleum Gas Institute.

Charles A. Cone has been elected president of the newly organized **Oil States Engineering Company**. He had been with Dresser Engineering Company for the past 23 years and served as vice president.

Charles A. Cone

Oil States designs and erects pumping stations, compressor stations and gas products plants. Other officers of the firm include W. G. Storey, former vice president of Trend Construction Company, who has been named vice president; and A. C. Young, former chief mechanical engineer for Dresser Engineering Company, is secretary-treasurer.

A. C. Laugharne has been made treasurer of the **Canadian Gas Association**. Laugharne has been with United Fruit Company and Aluminum Goods Ltd. He is a member of the Certified General Accountants Association of Ontario.

Stephen H. Baer has been chosen to fill the newly created post of public relations director for **Pacific Lighting Gas Supply Company.**

Baer had been news-publications bureau manager of Southern Counties Gas Co. He has been with Southern Counties since 1954. Previously he had been associated

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Electrical Mechanical Division

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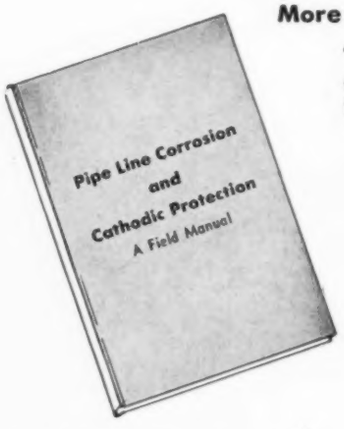
More comments on this new Handbook:

"... a most practical on-the-job manual for men concerned with pipe line corrosion. We are ordering copies for each of our district engineers."



Pipe Line Corrosion and Cathodic Protection

By MARSHALL E. PARKER

This Handbook, written by Marshall E. Parker, consultant, is designed as a practical field manual. It is a 108-page pocket-size volume printed first as a popular series in WORLD OIL. The Handbook is illustrated with many charts and drawings and is completely indexed by subjects.

It presents comprehensive data on Soil Resistivity Surveys, Potential Surveys, Line Currents, Current Requirements, Rectifier Systems, Ground Bed Design, Magnesium Anodes, Stray Current Electrolysis, Interference in Protective Systems, Operations and Maintenance, and Coating Protection and Testing.

An appendix has been added of technical data on Underground Corrosion, Basic Principles of Cathodic Protection, Properties of Metals and Attenuation Equations. Order copies of this practical Field Manual now for each of your field men. Price $3.

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with Bishop & Associates, public relations and advertising firm. He was assistant publicity director of both Los Angeles Chamber of Commerce and Los Angeles Junior Chamber of Commerce.

D. A. Schafersman

H. E. Boomer

Eight appointments have been made by **Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company** and **Natural Gas Storage Company of Illinois,** all affiliates.

Hobert E. Boomer was named superintendent of pipe lines; Dale A. Schafersman is the new field superintendent of compressor stations; and Robert D. Means becomes superintendent of Station 304 Marshall, Texas, for Texas Illinois Company.

NGPL promotions include William P. Lincoln, named assistant superintendent of Station 112 and gasoline plant 152 Stinnett, Texas; C. J. Fitzgerald replaces Lincoln as superintendent of Station 108 Truro, La.; Marion E. Shelor replaces Fitzgerald as superintendent of Station 103 Mineola, Kan.; and George R. Brindle was named district superintendent of gas measurement.

Burman F. Olson has been named superintendent of Station 201 of Natural Gas Storage Company near Herscher, Ill.

Kirby E. Crenshaw has been elected president of **Cities Service Gas Company.** He replaces **Harry D. Hancock** who is retiring after 46 years service with the company.

K. E. Crenshaw

Crenshaw has been with Cities Service since 1930 and served in various capacities on the company's pipe line system until 1940. He served as assistant manager of the Natural Gas department of Cities Service Petroleum and in 1956 he was named executive vice president.

Max L. Knotts of **Oklahoma Natural Gas Co.** has been promoted to manager at El Reno. He succeeds Wayman E. Humphrey who has been elevated to sales manager of the Muskogee district.

Standard Oil Company (Ohio) announces two changes in personnel in the Transportation and Marketing departments. **Henry W. Pattison,** manager of Transportation department with headquarters in St. Louis will be directly responsible to the president for the crude oil and petroleum product transportation activities of the company. **Joseph D. Harnett,** vice president of the company will move from St. Louis to become assistant to **Samuel H. Elliot,** vice president-marketing, at company

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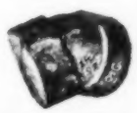
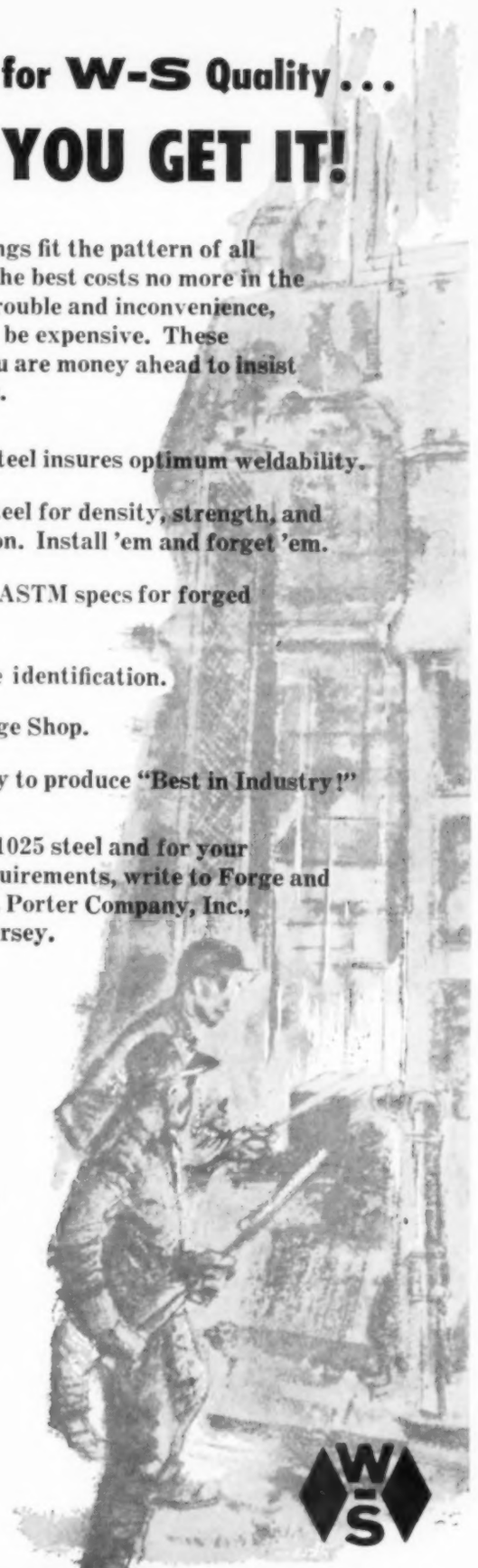


ROUGH FORGING AFTER TRIMMING

FINISHED FITTING



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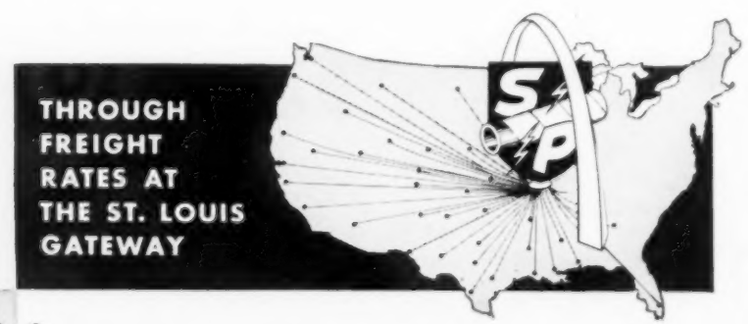

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offices in Cleveland. He will continue as vice president of the firm.

Pattison joined Sohio's Transportation department as staff assistant in 1946. He became assistant to vice president for transportation in 1952; was named general superintendent of transportation operations in 1956; and manager of transportation in 1957. Harnett has been with Sohio since 1941. He was made assistant chief engineer of **Sohio Pipe Line Company** in 1944. In 1947 he became superintendent of pipe line operations; in 1954 was appointed manager of transportation department, and in 1957 he was elected vice president of the company.

J. S. Bullington has joined **Northern Natural Gas Company** as senior industrial representative in the Department of Marketing, Economic Research and Area Development.

J. S. Bullington

Bullington had been director of Industrial Development division of the Oklahoma State department of Commerce and Industry for three and one-half years before moving to Northern. He has served as chamber of commerce manager at Wagoner and Vinita, Okla., and as a director of the Ozark Playground Association.

L. Clyde Olpin, secretary and treasurer of **Mountain Fuel Supply Company** has retired for reasons of health.

Olpin has been a director of the company since 1940 and has been secretary and treasurer since 1951. He joined **Utah Gas and Coke Company** in 1923 and was made assistant treasurer in 1929. In 1935, Utah Gas and other firms merged to form Mountain Fuel Supply Company, and Olpin became assistant secretary and treasurer.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, and JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF PIPE LINE INDUSTRY, published monthly at Houston, Texas, for October, 1958.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Wm. G. Dudley, 4742 Banning, Houston, Texas; Editorial Director, Warren L. Baker, 5524 Cherokee, Houston, Texas; Editor, Melvin A. Judah, 3311 Sackett, Houston, Texas; Managing Editor, Wallace Fitzgerald, 5423 Lymbar, Houston, Texas; Business Manager, Robert M. de Sombre, 4410 Ingersoll, Houston, Texas.

2. The owner is: The Gulf Publishing Company, Houston, Texas; June Wooden Bliss, Houston, Texas; June Wooden Dudley Bliss—Trustee, Houston, Texas; Mrs. Grace C. Carter, Dallas, Texas; Mrs. Margaret D. Cashman, Beaumont, Texas; Drum & Company, c/o Trust Department, Houston, Texas; P. Stinson Dudley, Eldorado, Texas; Ray L. Dudley (Deceased), Houston, Texas; Wm. G. Dudley, Houston, Texas; William V. Gross, Alpine, Texas; Mrs. Carolyn Dodson Keeble, Abilene, Texas; Mrs. Anita S. Lane, Houston, Texas; Charles H. Lane, Houston, Texas; James William Nelson, Baytown, Texas; Tom W. Nelson, Houston, Texas; Mrs. Sallie Windham Ridley, Houston, Texas; Walter Gage Sterling—Trustee, Houston, Texas; O. R. Waller, Chicago, Illinois.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 19th day of September, 1958.

P. J. AUCOIN

(Seal) Notary Public in and for Harris County, Texas. (My commission expires June 1, 1959.)

For more data on advertised products, use Readers' Service Cards, last page.

WHO'S MEETING WHERE

October

NACE, Southeast Regional meeting, Richmond, Oct. 6-7.

NACE, Northeast Regional Conference, Hotel Somerset, Boston, Oct. 6-8.

California Natural Gasoline Association, 23rd annual fall meeting, Huntington-Sheraton Hotel, Pasadena, Calif., Oct. 9-10.

OIL PROGRESS WEEK, Oct. 12-18.

American Gas Association, annual convention, Atlantic City, N. J., Oct. 13-15.

National Electronics Conference, Hotel Sherman, Chicago, Oct. 13-15.

ASME, American Society of Lubricating Engineers, conference on lubrication, Statler Hotel, Los Angeles, Oct. 13-15.

ASCE, Civil Engineering Show, annual convention, Hotel Statler, New York, Oct. 13-17.

Southwest Kansas Petroleum Industry, Sixth Annual Gas Measurement Institute, University of Kansas, National Guard Armory, Liberal Kansas, Oct. 15-16.

NACE, North Central Region, Cincinnati, Oct. 15-17.

Society of Petroleum Engineers of AIME, Southern California petroleum section, Biltmore Hotel, Los Angeles, Oct. 16-17.

Permian Basin Oil Show, Odessa, Texas, Oct. 16-19.

NACE, South Central Regional Conference, Roosevelt Hotel, New Orleans, Oct. 20-24.

Society of Automotive Engineers, national diesel engine meeting, Lord Baltimore Hotel, Baltimore, Oct. 22-24.

Independent Petroleum Association of America, annual meeting, Statler-Hilton Hotel, Dallas, Oct. 27-28.

American Institute of Electrical Engineers, general meeting, Pittsburgh, Oct. 26-31.

New England Gas Association, Operating division, Sheraton-Kimball, Springfield, Mass., Oct. 30.

New England Gas Association, Accounting division, Statler Hilton Hotel, Hartford, Conn., Oct. 31.

Natural Gasoline Association of America, Southern Regional meeting, Carlton Hotel, Tyler, Texas, Oct. 31.

November

Society of Automotive Engineers, national fuels and lubricants meeting, Mayo Hotel, Tulsa, Nov. 5-6.

Louisiana Polytechnic Institute, School of Engineering, Seventh Annual Instrumentation Conference, Ruston, La., Nov. 6-7.

Transportation Club, Petroleum Industry, annual meeting, Bismarck Hotel, Chicago, Nov. 10.

API 38th Annual Meeting, Conrad Hilton Hotel, Palmer House and Congress Hotel, Chicago, Nov. 10-13.

NACE, Western Region, fall meeting, Statler Hotel, Los Angeles, Nov. 17-19.

ASCE, Structural division and Kansas City section, Conference on Electronic Computation, Kansas City, Nov. 20-21.

Natural Gasoline Association of America, Panhandle Plains regional meeting, Herring Hotel, Amarillo, Texas, Nov. 21.

ASME, annual meeting, Statler and Sheraton-McAlpine Hotels, New York, Nov. 30-Dec. 5.

December

NACE, biennial short course on cathodic protection, University of Illinois, Dec. 9-13.

January

NACE, Canadian Eastern Regional meeting, Montreal, Quebec, Jan. 12-14.

February

NACE, Canadian Western Regional meeting, Calgary, Alberta, Feb. 12-13.

Smithco pioneered the development of this rugged cooler for severe application. Its functional design, with *excess* cooling capacity, has met and overcome *every challenge* of extreme weather and operating conditions.

The "D" series cooler, latest in the growing tradition of fine Smithco Air Coolers, combines years of qualified engineering experience with the newest manufacturing methods to give you the most dependable unit in it's field.

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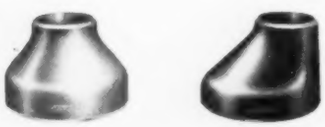

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Complete encirclement saddles.

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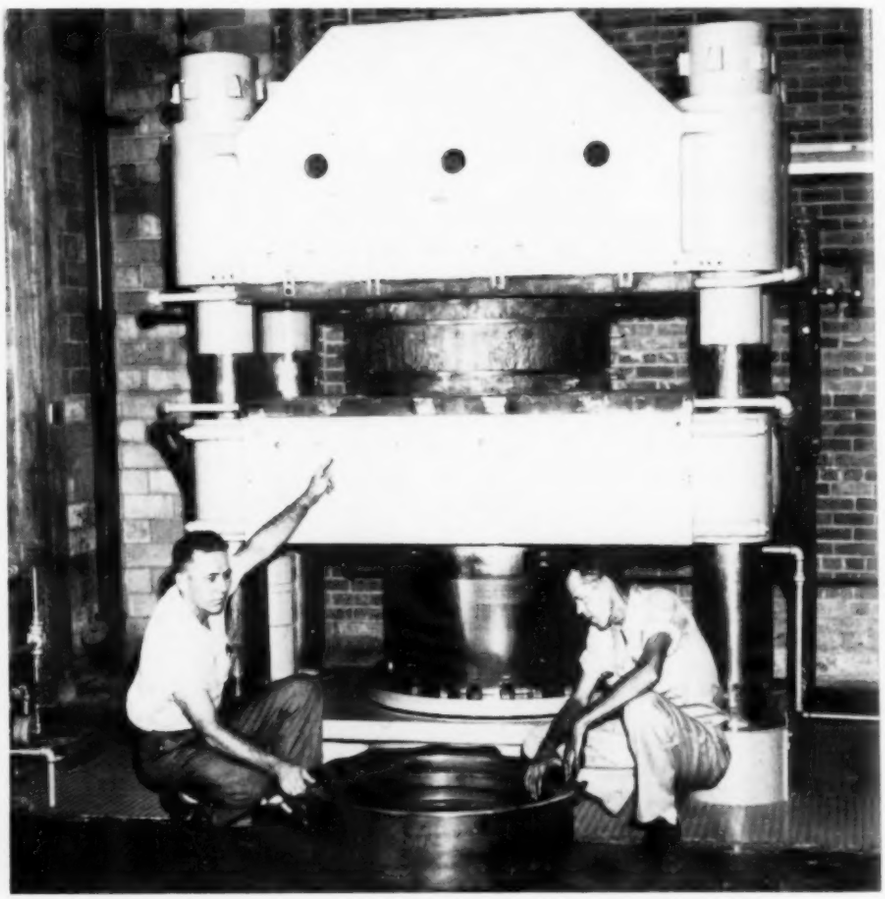
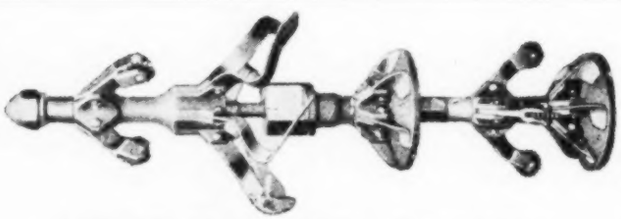
What's Happening among SERVICE and SUPPLY MEN



Hydraulic Rubber Press Installed at F. H. Maloney Co.

F. H. Maloney Co., presently undergoing a major expansion program which includes the construction of two new buildings, recently installed this 1,200-ton hydraulic rubber press to mold rubber and plastic parts to serve the pipe line and oil industry. W. E. Seals, plant engineer, and F. J. Sissom inspect a molded part from trial runs of the new 50 by 60-inch press.

Go-Devil



Standard Model Northrup Go-Devil with leather disc drivers

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G. E. Doty

F. A. Furgusson

C. W. Cook

R. L. Briggs

Doty Named Vice President Of Grove Valve and Regulator

George E. Doty has been named vice president and general manager of Grove Valve and Regulator Company. Other appointments announced by Grove include three regional sales managers and a service manager.

W. J. Hancock

R. L. Briggs will serve as central regional sales manager with offices in Tulsa; W. J. Hancock will head the eastern region with headquarters in Houston, and C. W. Cook will direct western region sales with offices in Houston. F. A. Furgusson, Houston, will have nationwide responsibility as service manager for the company.

Doty will be headquartered in Grove's Oakland offices.

Parsons Company Appoints Roy V. Smith District Manager

Roy V. Smith has been appointed sales representative of the North-Central district for Parsons Company.

Roy V. Smith

Included in Smith's district are the Dakotas, Minnesota, Nebraska, Iowa, Kansas, Missouri, Illinois, Indiana, Wisconsin and upper peninsula of Michigan and Kentucky. He will succeed John Harvey who has been moved to the South Central district.

Smith had been a field serviceman for Parsons for two years before his sales appointment.

United States Steel Transfers Ray L. Parrish to Chicago

Ray L. Parrish has been transferred from Calgary, Alberta, Canada to Chicago as United States Steel Oil Well Supply Division area manager, pipe line and refinery equipment.

Parrish joined Oil Well in 1948 as district engineer, pipe line and refinery sales. He became area manager at Calgary in 1952.

Square D Company Promotes Kartalia to General Manager

Square D Company has appointed Mitchell P. Kartalia general manager of Marketing division. He will be responsible for all Marketing division programs, including distributor relations, field office operations, national advertising, market research, product development liaison and export activities.

Kartalia had been sales manager of the company's Equipment division. He succeeds Frank Roby, who has resigned.

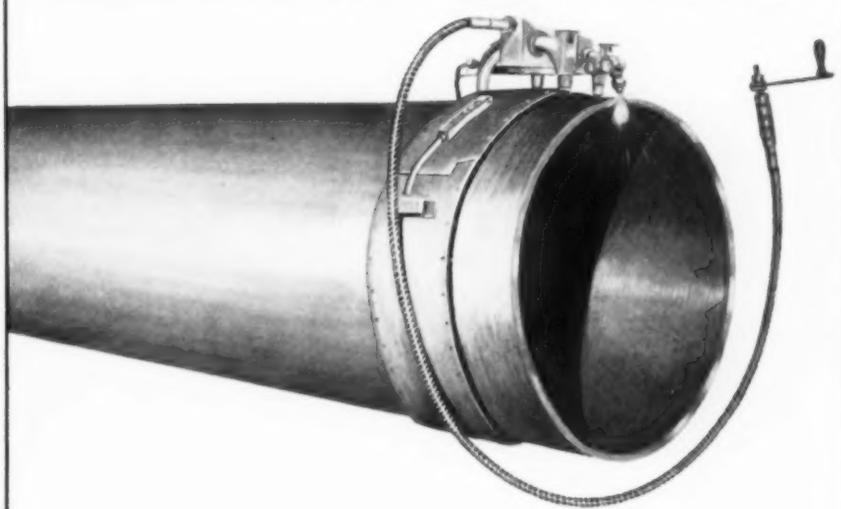
Joy Manufacturing Company Elects George E. Clark Director

George E. Clark, president of The Adams Express Company, has been elected a director of the Joy Manufacturing Company.

Don Rose, general counsel and a member of the board of directors, recently retired and has been succeeded by his son, J. Evans Rose. L. F. Rains, chairman of the executive committee, has retired from

BEVELS 6" PIPE

BEVELS 48" PIPE



C-R-C IMCO BEVELERS fit all pipe sizes 6" to 48" O. D., cut perfect bevels, and out-of-round pipe, too. Single lightweight unit does work of several, costs you less to buy and use.

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For additional information see page 108, Pipeline Composite Catalog.

The CRC IMCO Pipe Beveling Kit contains a complete range of bands for beveling a variety of pipe sizes. With this convenient selection of sizes, the operator need only make one trip to handle all pipe beveling requirements including back beveling. The sturdy steel case and number of bands are optional.

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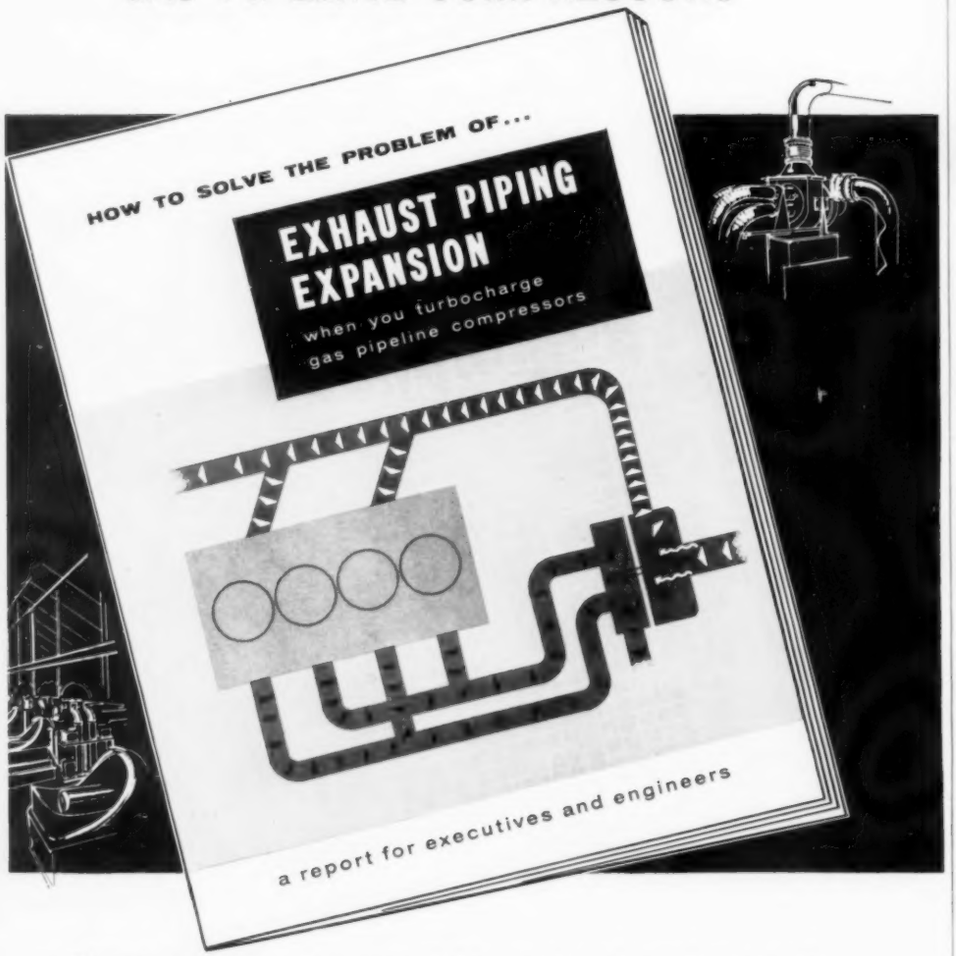
HOW TO SOLVE THE PROBLEM OF...
EXHAUST PIPING EXPANSION
when you turbocharge gas pipeline compressors
a report for executives and engineers

Write today for your free copy of this easy-to-read report on a most important and lively topic—*increasing gas pipeline capacity by turbocharging existing compressors in the field.* The report tells you the dollars-and-cents facts that led an important gas pipeline company to a complete turbocharging program.

And it also tells about the apparently insurmountable problems of expansion and vibration that arose when the exhaust piping became an integral part of the operating loop—and how the company's engineers, with the help of expansion joint experts from Flexonics, were able to solve the problems.

Whether or not you are considering a field turbocharging program, you'll want to know how three years of close cooperation developed a solution that is both simple and logical—a typical Flexon result. Send for your copy of the report, today.

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that position but will remain as a director of the company.

Dresser Selects J. P. Gasser Executive Vice President

J. P. Gasser has been named an executive vice president of Dresser Industries, Inc. Gasser, formerly executive vice president of Seaboard Oil Company, will direct activities of Lane-Wells, Ideco, Inc., Magnet Cove Barium, Security Engineering, Well Surveys, Dresser Dynamics, Southwestern Industrial Electronics, Hermetic Seal Transformer Co., and Dresser Turbodrill Division.

J. P. Gasser

Gasser joined Milham Exploration Company, the predecessor of Seaboard, in 1929. He was made a vice president in 1950 and named to the board of directors in 1951.

R. C. McDonald Appointed District Manager of Clark Bros.

Clark Bros. Co. has named R. C. McDonald New York district manager succeeding Robert J. Spears who has been promoted to assistant general sales manager.

R. C. McDonald

McDonald joined Pacific Pumps, Inc., a member of Dresser Industries, and was transferred to Clark Bros. in 1949. He became manager of Philadelphia district office in 1953. In New York McDonald will supervise Clark sales activities in the New York, Pennsylvania and Washington, D.C. territories.

Bucyrus-Erie Co. Appoints Charles Parthum Promotion Manager

Charles Parthum has been appointed sales promotion manager for Bucyrus-Erie Co. Parthum has been director of public relations, sales promotion and advertising for Harnischfeger Corp. the past two years.

Prior to his association with Harnischfeger Corp. he had handled advertising and sales promotion with the Buchen Company.

Cleaver-Brooks Company Begins Expansion Program

Cleaver-Brooks Company has started an expansion program called operation "Third Phase." Included in the program are a 70,000 square foot addition to the company's Lebanon, Penn., eastern manufacturing center and a new 25,000 square foot production facility at Stratford, Ontario, Canada.

The $1 million Lebanon project, expected to be completed by December, will more than double production space of the plant. The Stratford plant will cost approximately $900,000. It will be erected on a 10-acre site within the city limits, and production will begin there early in 1959.

Acme-Newport

ELECTRIC WELD LINE PIPE*

IS QUALITY-MADE THROUGHOUT

All the knowledge and proficiency gained by this basic steel producer through 73 years of quality steelmaking are vital ingredients in Acme-Newport electric weld line pipe.

1. **Formed from superior electric furnace steel**
2. **Uniform physical properties in all directions, for higher circumferential strength**
3. **Uniform wall thickness, because skelp is true-to-gage**
4. **Scale-free surface**
5. **Stresses relieved in weld area by induction heating**
6. **Each length hydrostatically tested**
7. **Exceeds API and ASTM specifications**

***SIZES AND WEIGHTS AVAILABLE**

O.D.	Wall	Wt. Per Ft.
4½	.125"	5.84
	.142"	6.61
	.156"	7.25
	.188"	8.64
	.219"	10.00
	.237"	10.79
6⅝	.156"	10.78
	.188"	12.89
	.219"	14.97
	.250"	17.02
	.280"	18.97

ECONOMICAL WATERAIL-TRUCK DELIVERY

This Company is ideally situated on the Mississippi-Ohio River system and the great Cincinnati rail-truck hub. New barge facilities, 7 major railroads and 143 motor carriers enable Acme-Newport to give economical, dependable delivery to the entire area of the Middle West and South.

Acme-Newport Steel COMPANY

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What's New in EQUIPMENT

Safety Device on Crane

With a safety device attached to its boom this crane is protected against dangerous high voltage power lines. Designed to serve as an insulator for the high wires, the guard prevents the crane's boom from coming into direct contact with the power lines when the boom accidently swings into a line. The rods are plastic coated and attached to the boom with four 15 KV insulators.

Saf-T-Boom Protects Crane Operators

Saf-T-Boom Corporation announces development of a safety device for cranes, which protects construction workers from dangerous high voltage power lines.

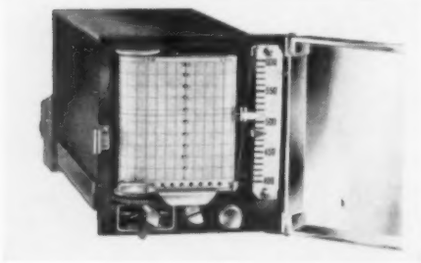
Invented by Art Thomas, the safety attachment is placed on the end of the boom and acts as an insulator for the power lines in case the boom should swing into the line.

The insulated guard rods are made of ¾-inch tubular steel and are connected to the boom with four 15 KV insulators. The rods are coated with plastic to give further insulation and prevent damaging wires if the boom makes contact with two wires. The Saf-T-Boom has been laboratory tested to withstand 30,000 volts without by-pass or leakage.

In field tests, the boom has been tested with 14,400 volts with inventor Thomas holding the dragline while the boom was in contact with the high wire.

For cranes which work over the wires instead of under them, Saf-T-Boom is designing a guard to fit on the bottom of the boom. The safety device can be installed in a short time and moved from one crane to another of the same size.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Control Stations

The Bristol Company announces two new control stations of the metagraphic type for use with process computer systems.

One receives 3-15 psi pneumatic signal from the computer that is the value at which the measured variable should be maintained for optimum yield. The controlled variable is continuously recorded and indicated, and the computer signal is continuously indicated. A third indicator normally indicates the valve top-pressure, but a push button allows indication of the regular output which is the set point when on automatic control.

The other station receives a 3-15 psi pneumatic signal of the valve pressure which should be maintained to provide optimum yield. It continuously records and indicates the controlled variable; continuously records a related variable; and continuously indicates valve top-pressure.

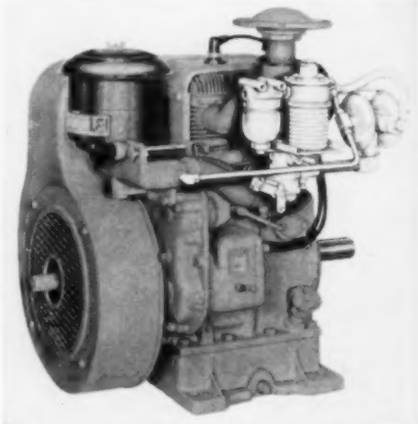
For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Telepulse Control System

The high speed telepulse selective supervisory control system is announced by Shand and Jurs Company. Designed for precise remote reading of process variables, the system also provides remote control of motors and valves. It is intended primarily for pipe lines and petroleum refineries.

The system is almost immune to error with its automatic error-check device. An element at the control station recognizes the number of groups of pulses received and accepts only messages with the correct number of groups. Any other combination causes sounding of a buzzer and an error is indicated. Special attention has been given to system expandability, plus ease of application, installation and maintenance. Basic elements may be joined in building-block fashion to construct small or elaborate systems.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

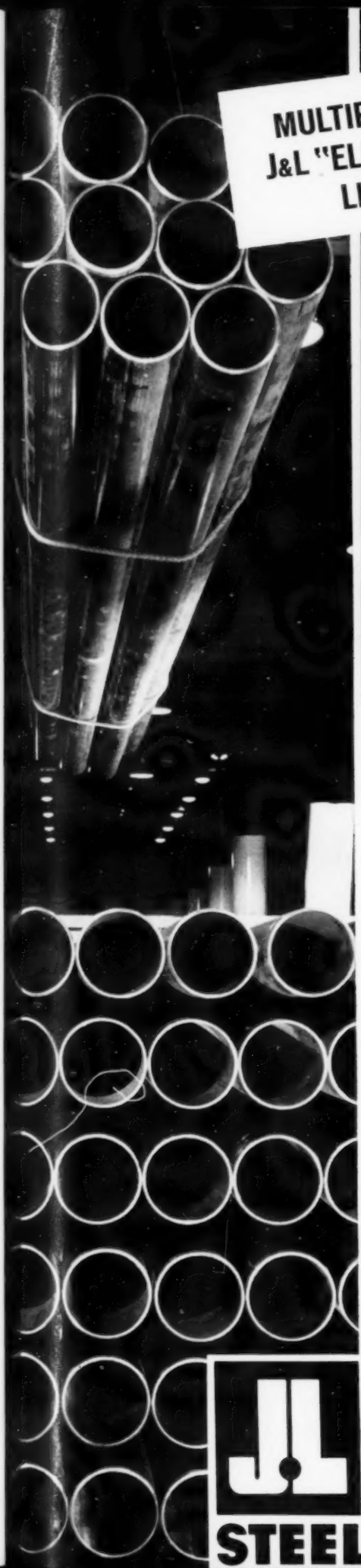


LPG Engines

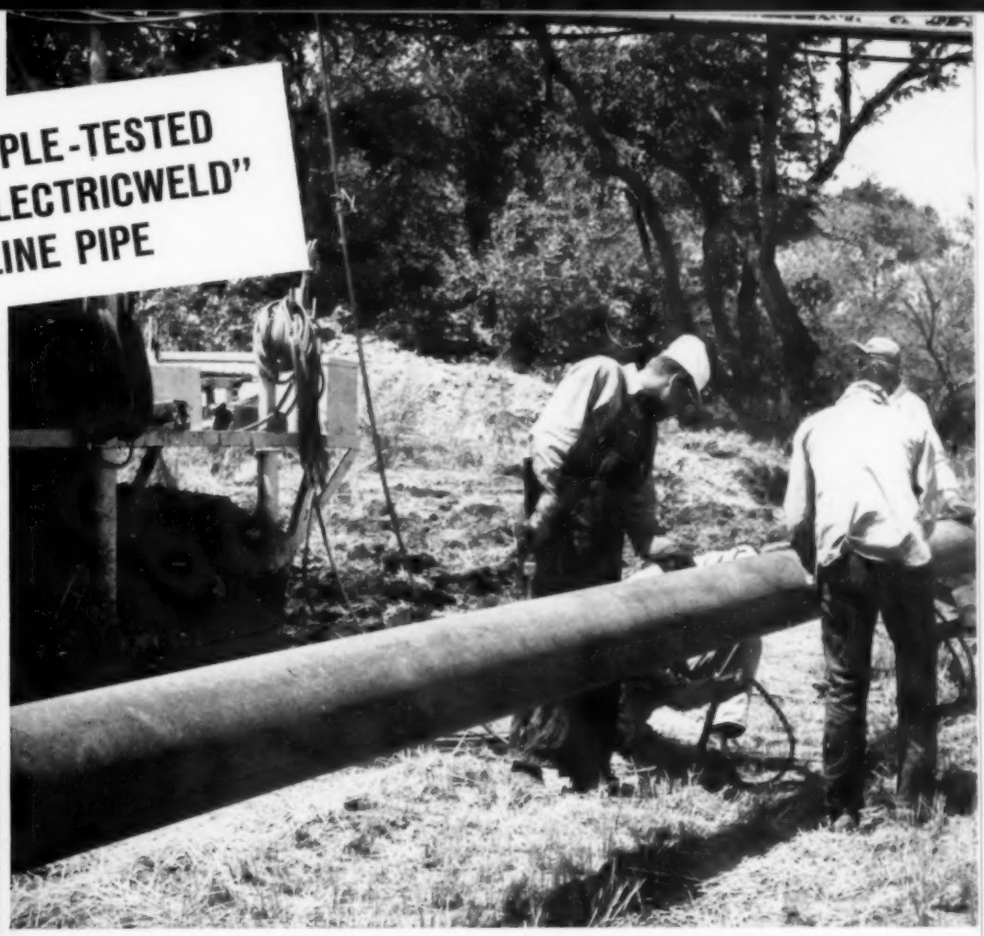
Wisconsin Motor Corporation announces a complete line of LPG engines to meet the expanding and increasing demands for original equipment engine components.

These engines offer the user such benefits as freedom from gum, lead and carbon deposits; complete fuel evaporation for maximum economy; greatly reduced percentage of carbon monoxide; complete combustion of fuel in engine cylinders and operating safety due to use of sealed fuel system. The heavy-duty, air-cooled four-cycle engines include a range of sizes from single cylinder models to two-cylinder and V-type, four-cylinder models in a complete power range from 2½ to 5[illegible] horsepower.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.



MULTIPLE-TESTED J&L "ELECTRICWELD" LINE PIPE



Welders on this Jayhawk Pipe Line Company installation report J&L Electricweld pipe is easy to weld. They installed 3109 tons of 10¾-inch O.D. and 3172 tons of 12¾-inch O.D. Electricweld pipe in this line. Both sizes are in .250 inch wall and Grade X46.

Jayhawk relies on J&L "Electricweld" line pipe for 78 miles of dependable performance

The Jayhawk Pipe Line Company, Wichita, used 42 miles of 10″ and 36 miles of 12″ J&L Electricweld line pipe in this new line from Plains to Valley Center, in Kansas. They find that J&L Electricweld line pipe bends readily, is uniformly round, is consistently top quality.

Electricweld line pipe is produced by Jones & Laughlin under most rigid quality controls. J&L, an integrated steel company, is able to control quality from ore through finished pipe. J&L takes every step to assure unsurpassed quality and dependability in Electricweld.

Before welding, the skelp edges are blasted with steel grit under 100 psi in a "Vacu-Blast" unit to clean the surface for perfect contact with the welding electrode. Electronic controls maintain exact welding heats at all speeds. After welding and trimming, the pipe passes through an induction annealing unit to assure uniform grain structure in the weld area.

Every length is thoroughly inspected through visual examinations, hydrostatic tests, flattening tests and magnaflux examinations. All J&L Electricweld line pipe is manufactured and tested in strict compliance with appropriate A.P.I. and A.S.T.M. specifications.

Electricweld line pipe is available from 6⅝ inches through 12¾ inches and in lengths to 60 feet. Investigate this superior-quality pipe for your next line. See your distributor, or write to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

J&L STEEL

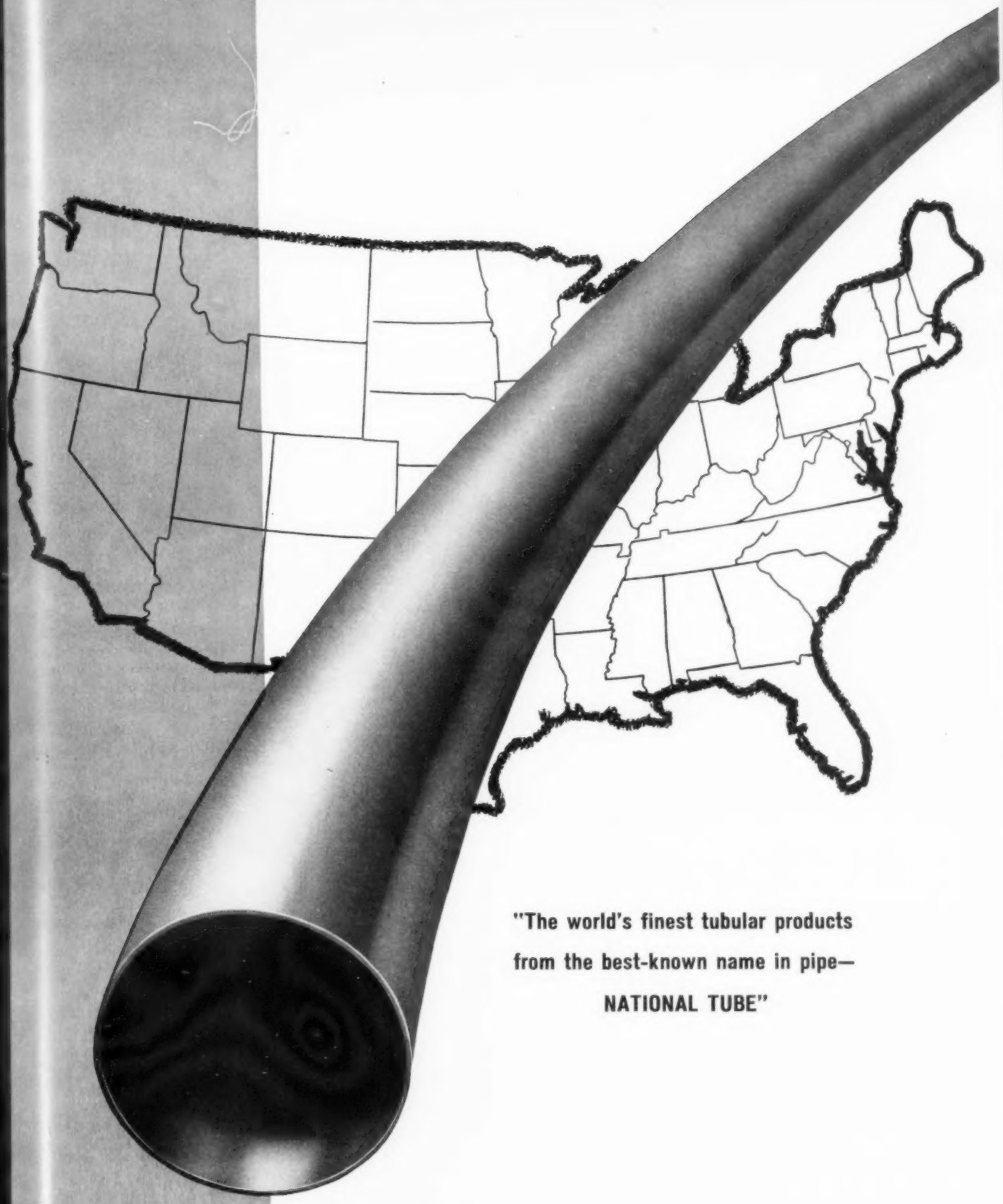
Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

NATIONAL LINE PIPE

reaches across America...

Seamless and Electric Weld



"The world's finest tubular products
from the best-known name in pipe—
NATIONAL TUBE"

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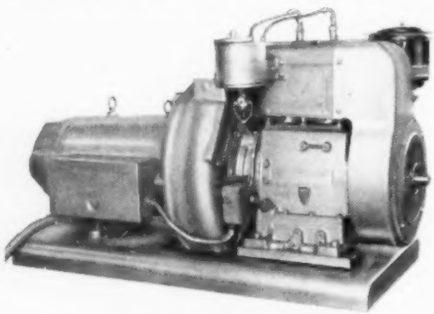
AMAZING U.S. MICRO-POWER



SENSES...

. . . the slightest drop in voltage. Actually *anticipates* power failure BEFORE voltage drops below a usable level.

ACTS...

. . . automatically to guarantee absolutely uninterrupted power. Not one precious second lost in load transfers.

SAVES...

. . . UP TO $300 PER MILE on new Micro Wave installations. Just one compact Micro-Power Unit replaces a costly array of complicated equipment.

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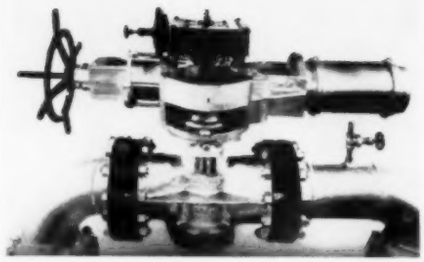
UNITED STATES MOTORS CORPORATION

102 W. FIFTH AVE. OSHKOSH, WISCONSIN

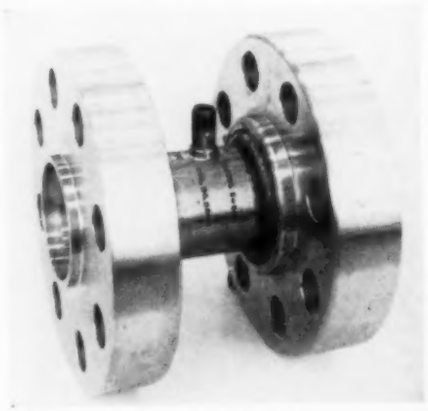


Valve Controller

Rockwell-Nordstrom valve regulators are now available with Republic positioners and controllers, manufactured by Republic Flow Meters Company, a subsidiary of Rockwell.

The valve regulator is a pneumatically controlled cylinder operated lubricated plug valve regulator designed to provide high-pressure large-volume gas regulation with minimum pressure loss. The controls consist of an accurate (vector type) pressure controller and a feed-back type valve positioner, which gives greater regulating sensitivity. An increase or decrease of downstream pressure causes a change in the output of the pressure controller, which causes the valve positioner to apply pneumatic power to the cylinder operator, thus repositioning the valve and controlling the downstream pressure at the set point.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.



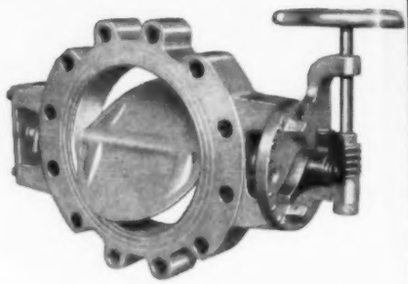
Turbine-Type Meters

Pottermeter Company announces a series of turbine-type meters for gas flow measurement, with accuracy of 0.5 percent of reading and a 10-to-1 flow range spectrum from .03 cubic feet per minute to more than 30,000 cfm, at any desired pressure.

Design and performance features include one moving part; relatively light weight; low maintenance factor; minimum outside diameter no larger than the line in which it is installed, and accuracy over a wide range. The Pottermeter unit transmits information by generating a pulse with a frequency directly proportional to the flow rate. The meters are constructed of a variety of materials and in a wide range of sizes to suit any application. In the inductance type meter the field of powerful magnets imbedded in the spinning rotor generates this signal in an externally-mounted pick-up coil to drive totalizers, counters, rate indicators, recorders and control devices which may be at locations thousands of feet away.

For more data, circle **No. E6** on Readers' Service Card, last page this issue.

ROCKWELL WAFER BUTTERFLY VALVES



For dependable flow control and wedge-tight shut-off of air, gases, steam and any liquids or semi-solids at pressure differential to 150 psi—

For use in power generating, cooling, refrigerating, dust collecting, compressing, processing, refining, gas transmission, combustion control, waste disposal and water works—

For easy, space-saving installation at lower cost.

They're built for HEAVY DUTY

- **Slim-trim—compact.**
- **Smallest face-to-face dimension; require but one set of flange bolts.**
- **Lightweight but rugged.**
- **Made of any metal or rubber-lined.**
- **Use any manual or automatic operators.**
- **Standard sizes—4" to 36"; special smaller and larger sizes.**

Bulletin 580 tells how they meet your needs.

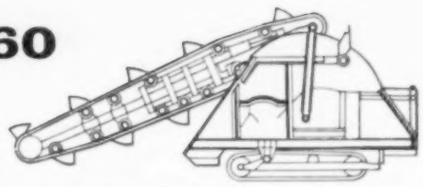
W. S. ROCKWELL COMPANY

2728 ELIOT STREET
FAIRFIELD, CONN.

There is an ALLEN TRENCHER for every job!

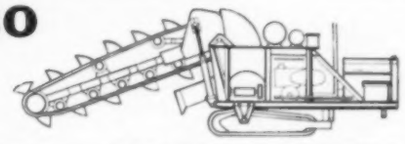
16-60

.40m. to 1.52m. wide. 4.26m. max. depth.



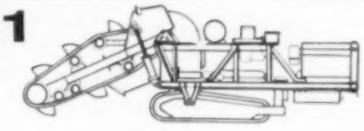
14-30

.35m. to .78m. wide. 2.59m. max. depth.

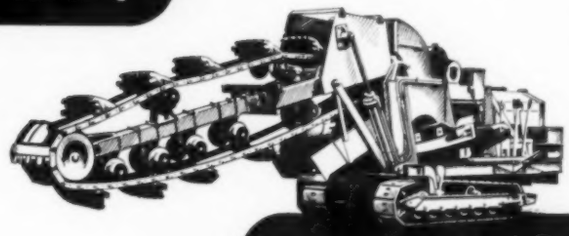


12-21

.30m. to .53m. wide. 1.82m. max. depth.



All over the world Allen Trenchers are proving their superiority for digging clean, precise trenches quickly, with freedom from breakdown and economy in operation. If you have a trench-digging problem, one of the Allen "built to last" range will provide the answer.



Full particulars of all Allen earth moving equipment sent on request.

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Serving the Pipeline Industry
with Lincoln Arc Welding Supplies

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WELDING SUPPLY CO.
is happy to announce their appointment as
WORTHINGTON
DISTRIBUTORS FOR
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PORTABLE ROTARY AIR COMPRESSORS
(Designed for the pipeline industry)

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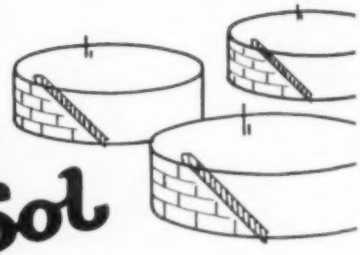
RECLAIM TANK BOTTOMS with BrakeSol



the most effective chemical for treating
PARAFFIN

The money you make on reclaimed tank bottoms by using BRAKESOL will be substantially more than the cost of treating . . . including chemical and labor. Safe for use in production, pipeline and refinery equipment . . . Contains no chlorides, sulphides or other halides.
BRAKESOL Treating Engineers have the experience and know-how to do a successful job. Contact them now!

Treating Engineers Available at These Locations

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EXPORT DISTRIBUTOR: THE NATIONAL SUPPLY CO., EXPORT DIVISION

Oscillating Axles

Spring-mounted oscillating front axles on the self propelled excavators solve problems encountered in bad terrain on construction jobs.

The rubber-tired, one-man operated Model Sp-107, introduced by Thew-Lorain, allows the front wheels to hug the ground so that the four-wheel drive can apply tractive efforts necessary to carry the excavator over the rough, soft ground of off-the-highway construction sites. There are always enough wheels in contact with the ground to kick the machine over the rough or soft spots; hang-up and wheel-spin are no problems.

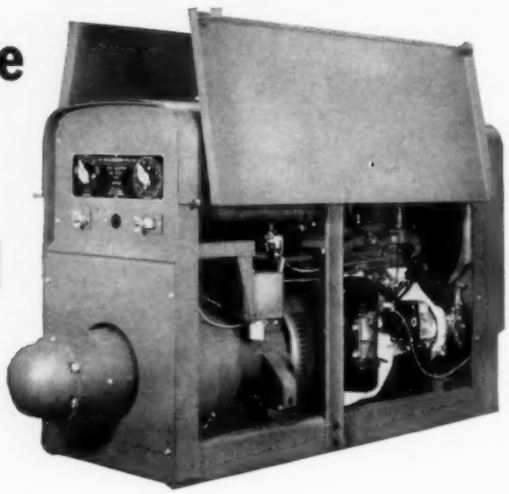
When maximum crane lifting capacities are needed for crane operation, the front spring action can be "locked-out" easily, to give solid-axle, full seven-ton capacity over front, rear and sides without setting outriggers.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Weldynamics

ARC WELDING AT WORK CUTTING COSTS

Lay more pipe per day with the improved 6090



Your old friend, the S-6090,
has some improvements that will help
you break more pipeline records for speed and low cost.

Now designated K-6090 this new welder offers

- **Increased horsepower** for long life of maximum output
- **Larger fuel tank** to run a 14-hour shift without refueling
- **More precise controls** to simplify selection of current and arc characteristics
- **Heavier body** to give greater protection against rugged field abuse

plus other features that make maintenance easier. For specifications and details write us!

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The World's Largest Manufacturer of Arc Welding Equipment

LINCOLN®

THE LINCOLN ELECTRIC COMPANY • DEPT. 5104 • CLEVELAND 17, OHIO

A. C. Power Source

Forney Generators, Inc., has made available a 2,000 watt, A.C. source for remote locations as a permanent installation on truck, tractor or car.

Armature is driven from engine's fan belt system and the field is excited by current from the 12-volt battery of the engine. A service outlet and voltmeter are included to permit engine operation at proper speed for the output required. It provides electric power at the flip of a switch and does not add to the power load of the vehicle while driving. The unit is quickly removed from one engine and installed in another whenever desired.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Diaphragm-Operated Valve

A line of diaphragm operated gas valves is offered by Amot Controls Corporation. The valve may be used as a remote operated valve for starting air on both gas and diesel engines, as well as a gas valve on gas engines.

The valve shuts off fuel gas and vents the manifold when used on internal combustion engine applications. When pressure is applied to the diaphragm, the vent port closes and the main ports open and admit fuel gas to the engine. When pressure is released, a spring closes the main ports and the large vent port vents the engine intake manifold which causes quick shut down. The valve body is made of cast iron with the working parts made of corrosion-resistant bronze and is suitable for operation in gas, air, water and oil.

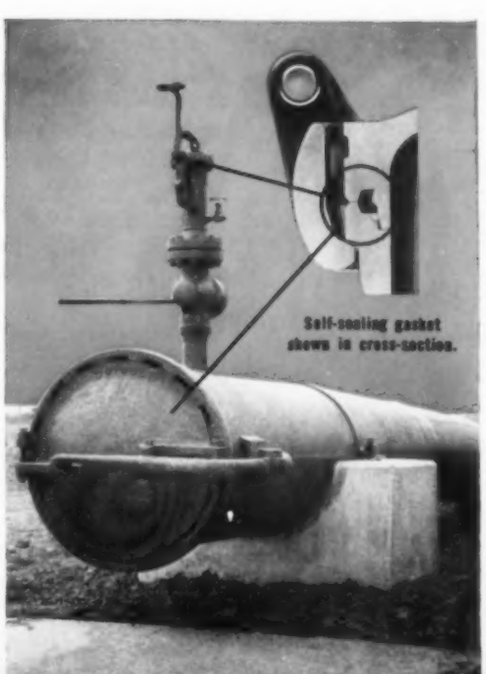
For more data, circle **No. E9** on Readers' Service Card, last page this issue.

If you are a pipeliner

you'll appreciate this self-sealing gasket in UNIBOLT scraper trap and blowdown closures

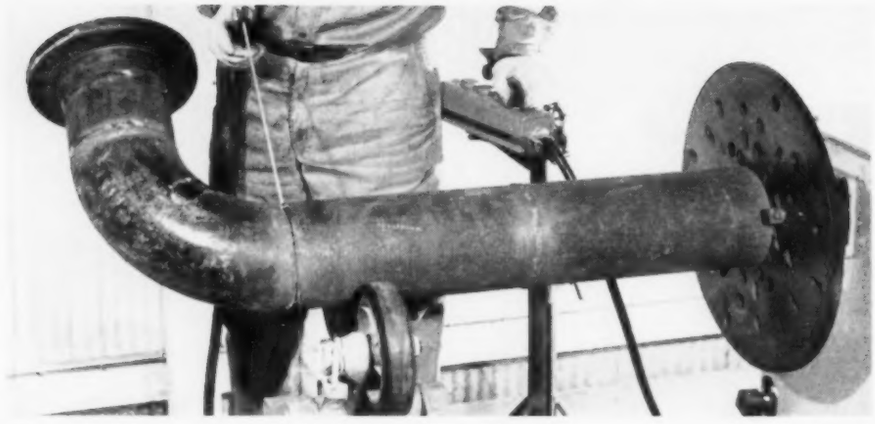
Little things . . . like the gasket for a scraper trap or blowdown closure for example . . . can be a big headache. But not this one. It is the self-sealing gasket used in UNIBOLT pipeline couplings. The UNIBOLT design makes line pressure do the sealing. And this design practically encloses the gasket in steel so that when the closure is opened and closed the gasket is hardly disturbed. Made of oil- and gas-resistant Hycar nitrile rubber, this gasket will last indefinitely under normal conditions.

UNIBOLT scraper trap and blowdown closures are hinged for easy operation. Release only two bolts and the closure swings open and shut like a door. No heavy lifting. No time-consuming multi-bolt flanges. See our detailed data in Pipe Line Composite Catalog and write or wire for any needed information.



THORNHILL CRAVER CO.

P. O. Box 1184, Houston, Texas



Pipe Machine

R. C. Porter Company announces a pipe machine for use in cutting, fitting and welding of pipe. Pipe from 1¼ inches to 12 inches and up to 25 feet in length can be worked by the illustrated model. Pipe up to 30 inches in diameter can be rolled for welding and flanges, and elbows to 12 inches can be reclaimed. Models for larger or smaller size ranges can be constructed.

With the pipe machine, alignment of pipe and fittings is mechanical, finished welds are cleaned quickly, and pipe fabrication is completed with less manpower in less time.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

ONLY the application-engineered

DATA GAGE*

REMOTE MEASUREMENT AND CONTROL SYSTEM

offers these exclusive advantages

NEW ACCURACY
- Only digital system with 1/16" accuracy independent of product gravity.
- Only system satisfactory for use in FLOATING ROOF TANKS.
- Only system to give reliable readings during blending turbulence.

NEW RELIABILITY
- Only system with POWER FLOAT (moving mechanical surface finder) which checks itself automatically.
- Transistors are used instead of short-lived vacuum tubes.
- A true digital system with unlimited-distance, error-safe telemetering.

NEW FLEXIBILITY
- Single dial control for both level and temperature measurement.
- 100 reading point capacity; applicable for alarm devices, valve and pump controls, remote transmission for data processing.
- Application-engineered approach gives you assured performance.

*Trademark registration applied for

Write for complete information, specify Bulletin M-601.

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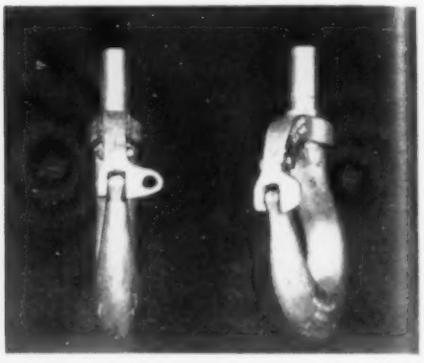


Hoist Hook Lock

E. D. Bullard Company announces a new locking mechanism for the company's safety hoist hook gate for use on large size hooks.

The mechanism locks the safety gate in place over the tip of hook creating greater strength to the gate. This "tip-lok" attachment keeps gate closed and load secure; the larger the hook, the greater the leverage against the locking mechanism at the shank. The lock has been added to safety gates on hooks sizes 13 through 17A.

This "tip-lok" automatically lifts open and drops closed upon contact with the tip of the hook. The locking tip of the gate is available with or without the ring, as illustrated. The ring makes it possible for remote operation when hook is used over intense heat or chemicals. The gate may be opened with a reach rod.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

Shopcoat

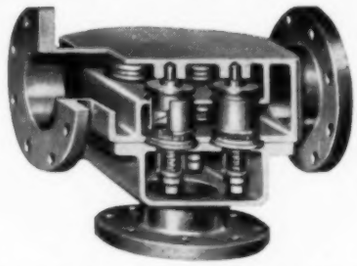
Dresser Manufacturing Division has developed a durable and effective shopcoat, Dresser Red-D, which will fulfill numerous unique and specified requirements of a pipe coupling shopcoat.

The Red-D will give over six months protection against corrosion, an important factor when couplings are kept in open storage at the job site months before use. The new shopcoat resists dirt adherence and any grease or oil accidentally spilled on the Red-D can be removed with gasoline or carbon tetrachloride without causing damage to the shopcoat.

It is compatible with over 95 percent of the field coating systems in use on pipelines and will aid materially in promoting a superior coupling coating job. All company pipe couplings (except compression fittings which are Bonderized) and pipe products are now shopcoated with Red-D.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

AMOT Engine Controls



AMOT is the best known name in controls for pipe line engines, and many pipe line companies have up-dated their installed equipment with the **AMOT CONTROLS** listed below.

- **THERMOSTATIC VALVES**
  For jacket water and lube oil temperature control.
- **MECHANICAL SAFETY CONTROLS**
  Shut down engine on high water temp. or low oil pressure.
- **SAFETY CONTROL SWITCHES**
  Sound alarms on high water temperature or low oil pressure.
- **VENTED DIAPHRAGM GAS VALVES**
  Shut off main gas supply to gas engines.
- **THERMOSTATICALLY ACTUATED AIR VALVES**
  For automatic fuel change over.

AMOT MAINTAINS REPRESENTATIVES IN PRINCIPAL CITIES
CATALOG AVAILABLE ON REQUEST

AMOT CONTROLS CORP.

FIRST ST. & NEVIN AVE. RICHMOND, CALIFORNIA

FISHER Leads Again!

New, Transistorized M-Scope Pipe Finder

Here's what exclusive Fisher transistorized design means to you:

- Greatest depth penetration
- Greatest tracing distance
- Pinpoint accuracy
- One year between battery changes
- Built-in battery testers
- 90% less maintenance costs
- Built-in Leak Detector circuit

only $220.00

SEND FOR FREE MANUAL "Special Pipe Finding and Leak Detecting Techniques."

M-Scope Electronic Witch Pipe Finder

New, Transistorized Leak Detector

- Finds leaks faster, more accurately
- Weighs 80% LESS than ordinary equipment

Send for FREE 1958 Catalog

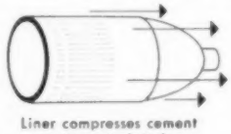
$295.00
Model CT Leak Detector

Fisher

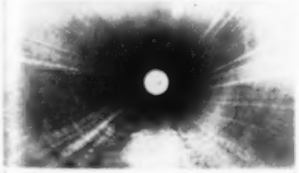
Fisher Research Laboratory, Inc.
Dept PI-3, Palo Alto, California

Geophysical Instruments Since 1932

there's a better way to get it done!



Liner compresses cement mortar onto interior



Gives smooth, continuous, water proof lining of correct thickness

Tate Process applies cement mortar lining to the interior of 4" to 16" lines quickly and economically . . . while the lines stay "in place." Permanently restores full flow coefficients. Reduces pumping and maintenance costs. Protects against corrosion, contamination.

Write for full information TODAY!

Specializing in Pipe Protection Problems
• Tate and Centriline "In Place" Interior Cement Mortar Lining • "In Plant" and "Railhead" Centrifugal Spinning of Cement Mortar or Coal Tar Linings – Somastic® Exterior Coating • Pipe Wrapping • Reclamation: Removal of Old Wrapping, Straightening, Blasting, Beveling, Testing.

PIPE LININGS
A Division of American Pipe and Construction Co.

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DIG FAST!

SHAWNEE.

"88" BACKHOE and SPECIAL Heavy Duty LOADER

Economy Priced!

Today's fastest backhoe. Digs 12' deep, dumps at 9'9", swings 188°. This hard-working tool reduces costs, requires minimum maintenance – it is versatile and moves easily from location to location. Built by the pioneer of the hydraulic backhoe.

Send for specifications and prices.

Loader Attachments:

Various sizes Utility and Material Buckets, Snow Bucket, Angle Dozer Blade, Bulldozer Blade, Crane Hook, Fork Lift and Street Broom.

Serving in many industries all over the world.

SHAWNEE MANUFACTURING CO., INC.
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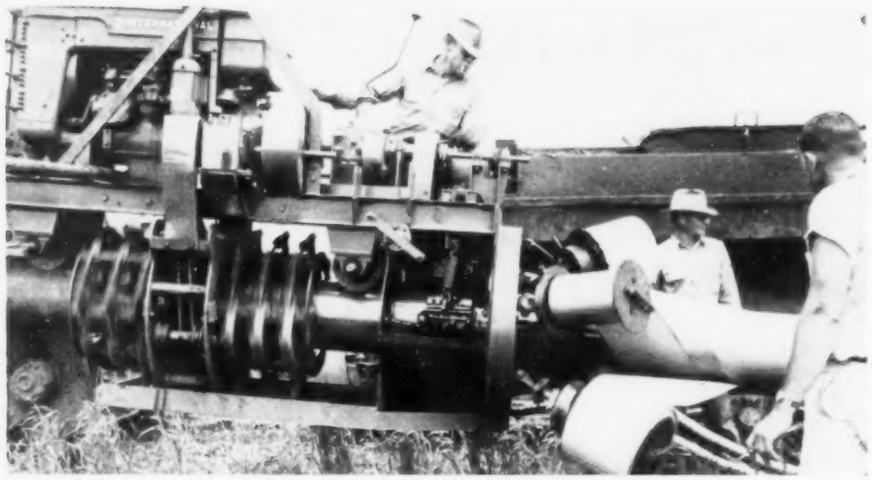


Coating Machine

A combination cleaning, coating and wrapping machine has been introduced by Crutcher-Rolfs-Cummings, Inc. The machine has been tested with the use of a hot innercoat of microcrystalline wax, applied directly after cleaning takes place.

Requiring no primer coat, the wax is sprayed and flooded directly onto the pipe immediately after cleaning operation, and is wrapped with a poly-vinylidene chloride plastic wrapper developed by the Trenton Corporation.

The machine will handle pipe from 3 inches through 36 inches in diameter and larger if desired.

(This item supplements Crutcher-Rolfs-Cummings data on Pages 107-110 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

INTEGRITY TO FINISH THE JOB . . .

A Quality of Houston Contracting Pipeliners

The men of Houston Contracting Company feel that a pipeline is not finished until the right-of-way has been completely cleaned up. Both pipeline owner and contractor benefit from this spirit of community welfare for better built pipelines by Houston Contracting.

Houston
CONTRACTING COMPANY
GENERAL CONTRACTORS
Laurence H. Favrot • R. P. Gregory • Geo. A. Peterkin

OIL • GAS
GASOLINE
WATER PIPELINES

2807 BUFFALO SPEEDWAY
HOUSTON 6, TEXAS

Lorry Crane

Insley Manufacturing Corporation announces production of a 30-ton lorry crane, Type WT, which can be supplied with three different truck mountings to meet varying axle load requirements of the various states.

The WT features an 8-foot wide deck with all operating machinery mounted low and well back of the center line of rotation. Power is transferred from the engine clutch to the operating machinery by a four-strand roller chain drive. All shafts are of high strength alloy steel with involute splining for added strength. Anti-friction bearings are used on high speed shafts. Basic boom is 35 feet high; pendant type boom suspension connects to stationary hubs at the boom point. Boom point is the open throat type and is constructed of high strength, lightweight alloy steel.

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Multiple-Seal Valve

The multiple-seal gate valve, a new leak-proof valve for aromatics, hydrocarbons and LPG, has been developed by Vernon Tool Co., Ltd. The gate valve features four separate seals, two precision metal-to-metal seals and two secondary "O" ring seals. This provides a positive line shut-off with greater economy; tightness of the shut-off can be proven at any time by means of a bleeder connection incorporated in the valve bonnet.

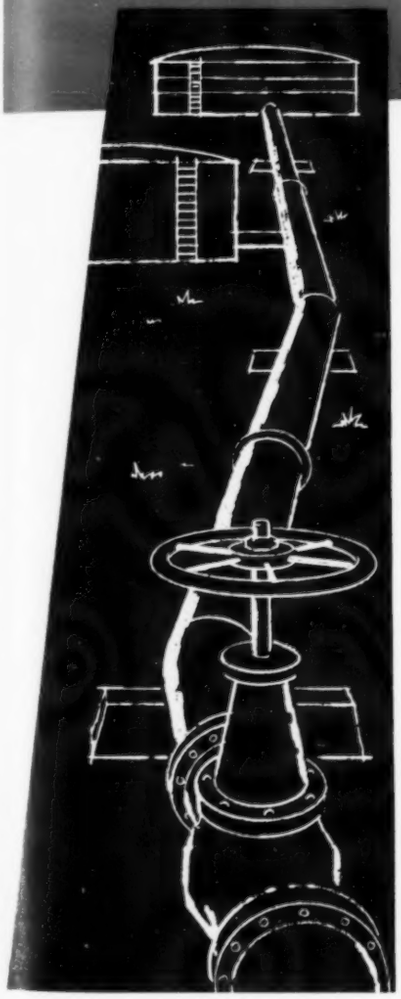
Valves are made of cast steel with stainless steel trim and all face to face dimensions.

(This item supplements Vernon Tool Co., Ltd. data on Page 404 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Sinclair Refining reports...

Instantaneous, accurate gaging with S&J Datalogger!



Sinclair's new S&J Datalogger permits reliable tank gaging regardless of time or weather conditions. In addition, the S&J Datalogger provides permanent records for checking each day's operation at Sinclair's Hartford, Illinois refinery.

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New Equipment Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card.

Lubricant Chart

Alpha-Molykote Corporation has issued a bulletin which contains a valuable chart for machine shop personnel to show where and how lubricants should be applied.

The chart indicates the equipment on which the lubricant promises to excel, the method of applying the lubricant and benefits which can be expected.

To get a copy, circle **No. E16** on Readers' Service Card, last page this issue.

Track Rollers

Caterpillar Tractor Company has released an eight-page booklet, "Don't Buy in the Dark" which discusses the make-up and maintenance of track rollers.

Each roller is reviewed in detail with drawings, cutaways and photographs to point up individual features. Information on roller rims, bearings, seals and shafts is included in the two-color booklet. Direction for proper lubrication and reconditioning are also given.

To get a copy, circle **No. E17** on Readers' Service Card, last page this issue.

Electrical Equipment

Crouse-Hinds Company announces a 12-page bulletin which briefly describes manufacturing facilities and electrical products.

Emphasis of the illustrated bulletin is stressed on the variety of equipment available in the four products lines condulet electrical equipment, floodlights, aviation lighting equipment and traffic control.

To get a copy, circle **No. E18** on Readers' Service Card, last page this issue.

Flange Matching Tables

Tube Turn Division of Chemetron Corporation offers an answer to the oil field storage problem of "what forged steel flange mates with what plug valve?" in its latest bulletin.

Forged steel flanges, rated according to intended service pressure at elevated temperatures, and lubricated plug valves, usually given WOG ratings, are properly matched in the bulletin. Bolting and gasket data are also provided.

To get a copy, circle **No. E19** on Readers' Service Card, last page this issue.

Insulation System

Allis-Chalmers Manufacturing Company announces a six-page bulletin which describes the "silco-flex" insulation system for motor and generator stator coils.

Basis of the system is asemi-organic silicone elastomer characterized by extreme chemical stability and retention of original properties under the most adverse conditions. Properties of insulation system explained in the bulletin include resistance to aging, abrasion, chemicals, corona, fire, moisture, oil, solvents, fungus, carbon black and arcing.

To get a copy, circle **No E20** on Readers' Service Card, last page this issue.

Magnetic and Motorized Valves

Mercoid Corporation has released a 24-page catalog illustrating magnetic and motorized valves for use with air, water, gas, steam, oil and refrigerants. Included in the catalog are specifications of the valves, solenoid coil rating tables, and two flow charts—one for liquid and the other for compressible fluids.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Meter Tubes

Daniel Orifice Fitting Company announces a 20-page catalog with features and specifications of Daniel Flangnek standard meter tubes. Standard units incorporating either Daniel senior or simplex orifice fittings are available for immediate delivery.

Included in the catalog are specifications on meter tubes, three section (transmission) units, high pressure meter tubes, special and modifications, power station units and special materials, metering station accessories and engineering design information.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Service Bulletin

A service bulletin, featuring a wide range of hydraulic and manual tools designed specifically for Caterpillar equipment, has been issued by Owatonna Tool Company.

Included in the 16-page bulletin are OTC hydraulic and manual pulling and installing tools for gears, bushings, drive sprockets, main bearings, grader wheel hubs, track pin presses to remove and install track pins and bushings, cylinder sleeve puller-installers and shop presses.

The bulletin also features a serviceman's tool set, plus other specialized items.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Track-Type Tractor

Caterpillar Tractor Company has published a brochure which illustrates and explains four years of improvement on the D8 track-type tractor.

The two-color bulletin describes changes in horsepower, 149 to 191; drawbar pull, 28,700 to 39,150; versatility, torque converter or direct drive; economy of operation and operator ease.

A large cross-section view of the machine is keyed to show the major improvements.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

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AND *ECONOMICALLY*
CONVERT YOUR "PICK-UP"
TO A MODERN *SERVICE* TRUCK!

Mount Stahl Utility Side Boxes on any make or model of pick-up truck. All-steel, welded, furnished complete with mounting brackets, bolts and instructions. Keep your tools dry, safe, organized. Thousands of pairs in use. *Write today for Literature and Name of Nearest Distributor.*

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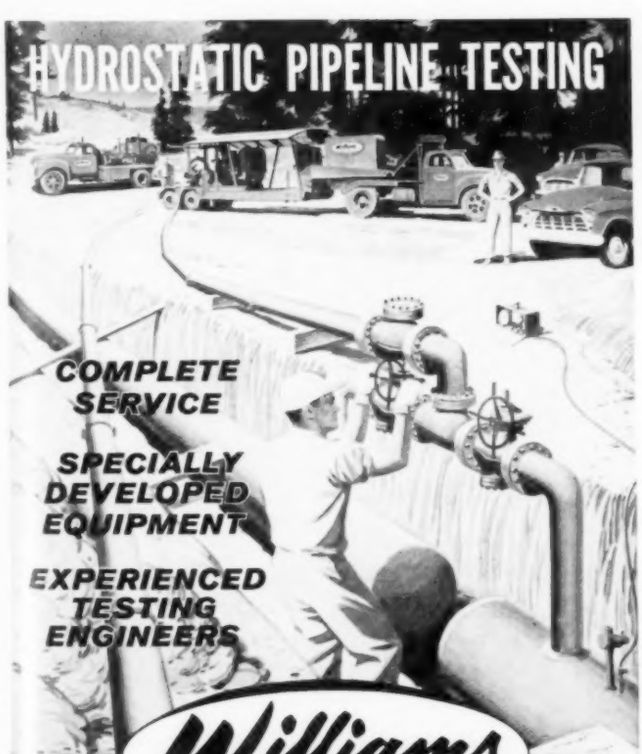

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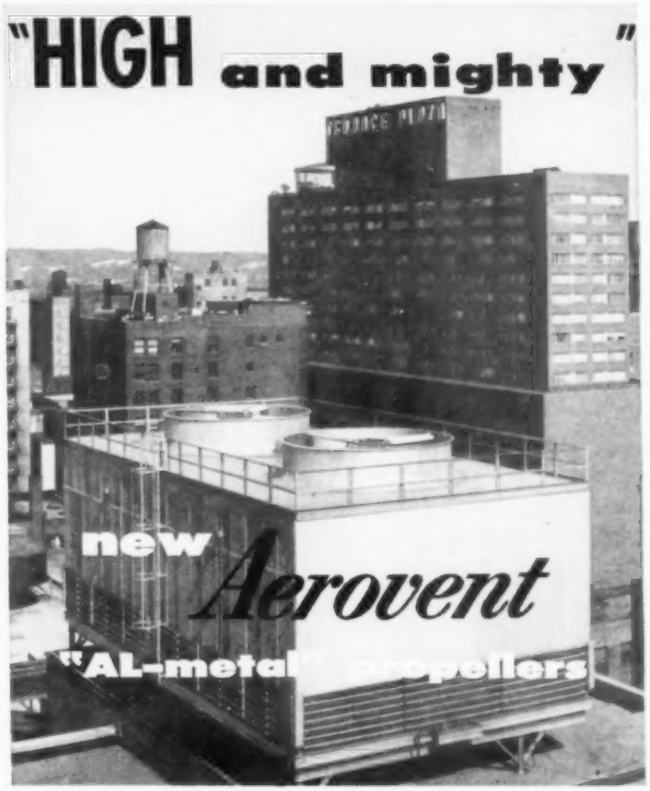

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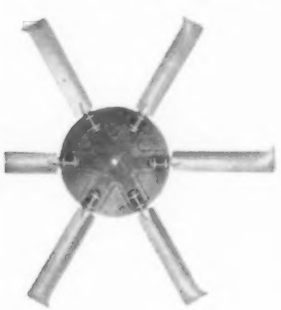

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Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

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Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in revolutionary new "T-Alloy".

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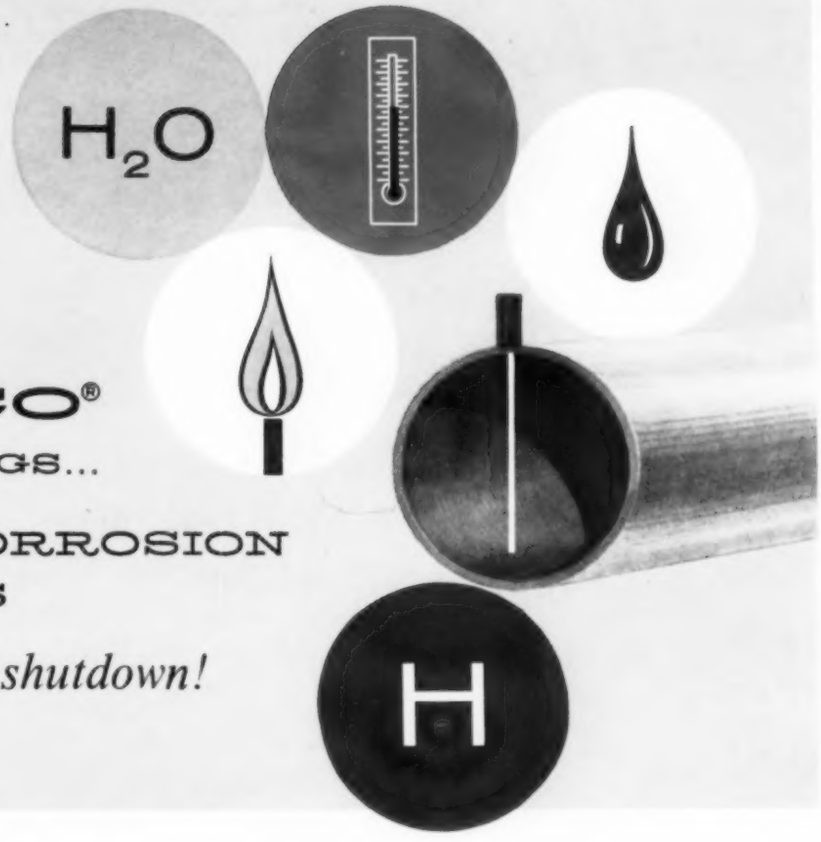

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ACCESS FITTINGS...

COMPLETE CORROSION SURVEYS

without system shutdown!

THE COSASCO ACCESS FITTING provides the key to successful corrosion survey work in transmission, storage, recovery and processing equipment. Previously, it had been difficult and costly—if not impossible—to run corrosion surveys inside pipelines and other pressure vessels without shutting down the system. Now, with Cosasco Access Fittings, corrosion surveys of all kinds can be made *under full operating pressures.*

CORROSION COUPON SURVEY. Enables the Corrosion Engineer to determine if corrosion is taking place. Grade 303 stainless steel coupon holder is installed through regular Cosasco Access Fitting body . . . can be easily inserted or withdrawn under pressure at any time. Holders are made in 3 categories adaptable to various line sizes and survey techniques. Corrosion coupons—available in standard lengths of 3″, 6″, and 8″, in any type of steel or rare metal—may be fully insulated from holders . . . remain unaffected by external soil conditions.

WATER SAMPLING SURVEY. Takes sample of line fluid for analysis. Special Cosasco water sampling plug with extension nipple and fluid catch attachment of S. S. 303 is inserted in Access Fitting body through main valve. An upper S. S. assembly consisting of a horizontal and vertical run, each with ½″ valve, is installed on the main valve. This permits taking a sample under full pressure and normal operating conditions to determine causes of corrosion.

THERMOCOUPLE SURVEY. Tells operator what part temperature is playing in corrosion problem. Cosasco thermocouple plug attachment (S. S. 303) is inserted in Access Fitting body and main valve is removed. Iron constantin wire is then pushed through gage carrier plug into position in the line. Thermocouple can be removed at will or hooked up to chart recorder for continuing temperature check.

ATOMIC HYDROGEN SURVEY. Discloses whether free atomic hydrogen is causing internal blistering. Cosasco hydrogen probe is installed through body of Access Fitting . . . can be easily withdrawn while vessel or line is on stream. Ball-check safety device protects against blowout or damage to gage should lower end of probe be damaged by excessive hydrogen in line fluid. Probe detects presence of free atomic hydrogen . . . gages rate of hydrogen diffusion.

RATE-OF-CORROSION SURVEY. Gives rate-of-corrosion reading electronically. Cosasco Corrosometer® Probe is installed under pressure through Access Fitting . . . quickly gives corrosion reading in increments of microinches without removing specimens or interfering with operations. Readings can be made in as little as 30 seconds without withdrawing the probe.

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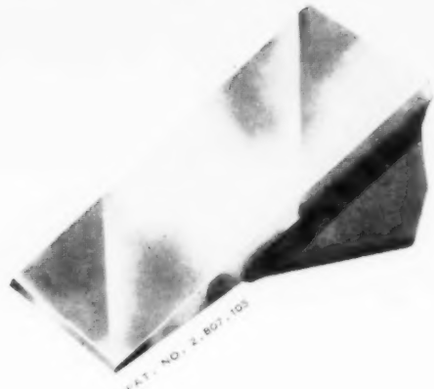

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